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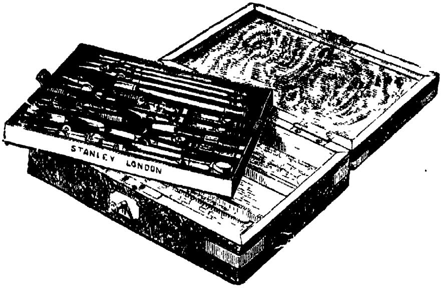

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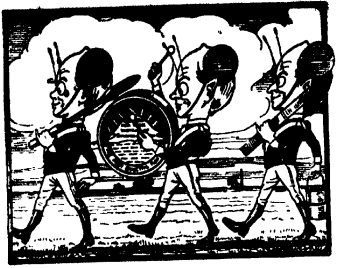

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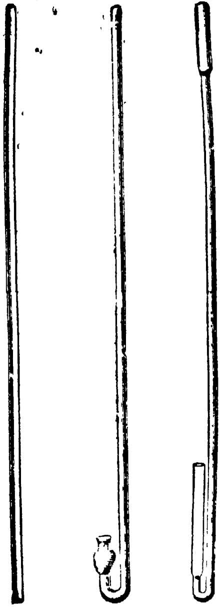

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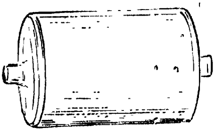

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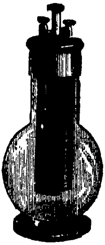

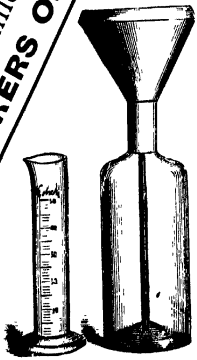

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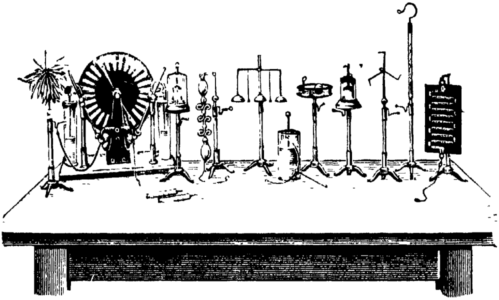

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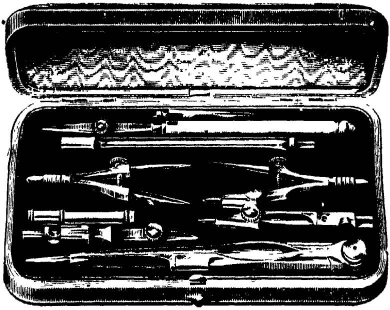

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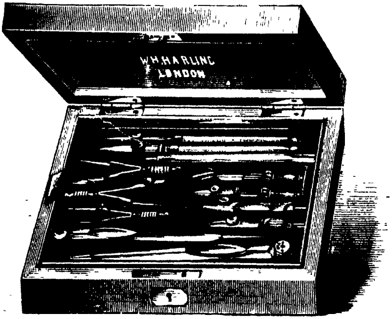

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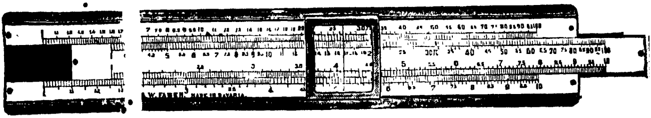

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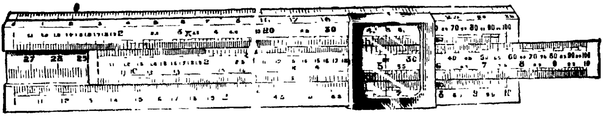

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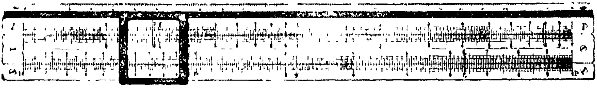

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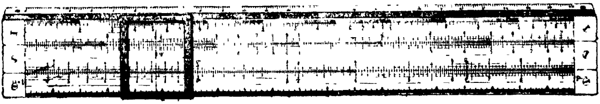

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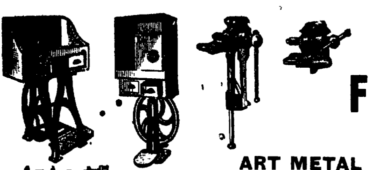

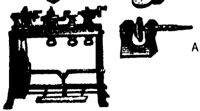

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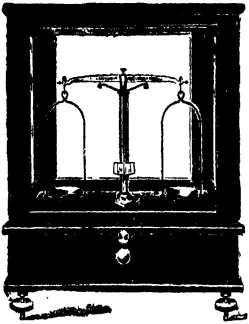

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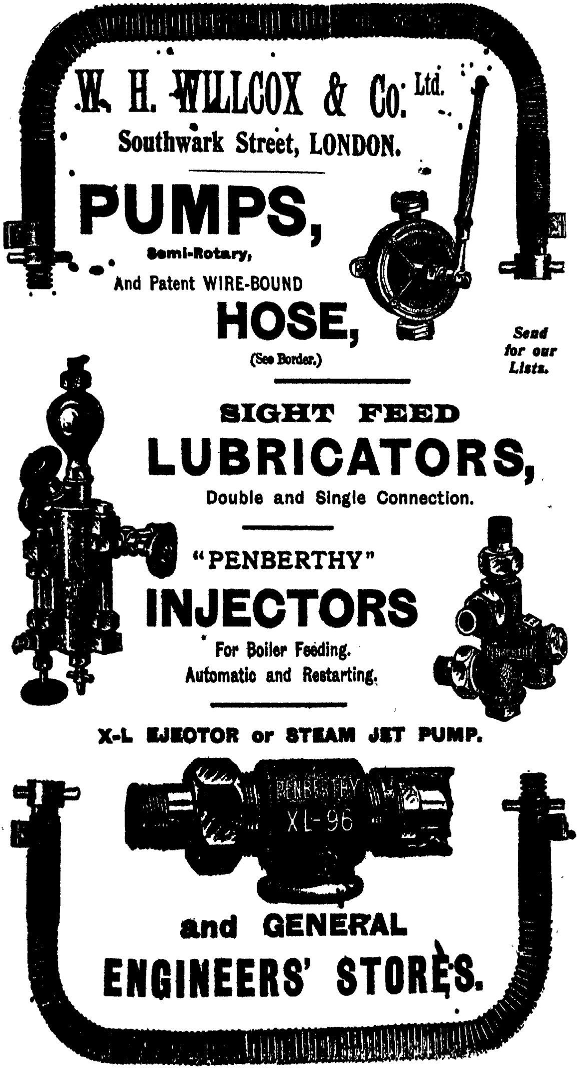

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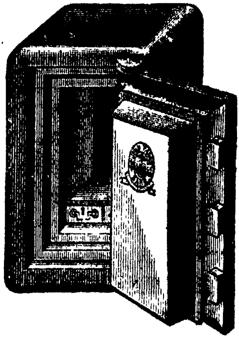

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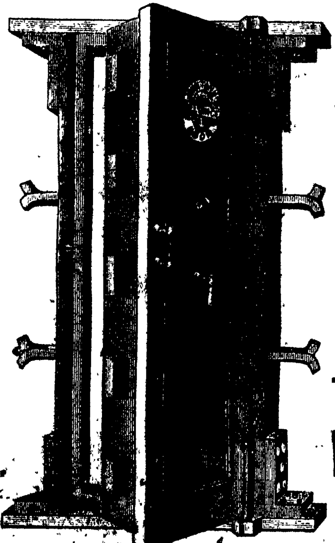

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WHEN collecting rainwater, as it falls, either for domestic use or any other purpose, the only practicable means of obtaining a useful quantity is by taking that which falls on roofs or similar large waterproof areas. As the average annual rainfall in most places in England is 25 in., and each inch represents half a gal., it will be seen that a roof having 2000 sq. ft. (in plan) will have no less than 25,000 gal. fall upon it in a year. If, for reasons about to be explained, one half of this goes to waste, there remains 12,500 gal., which is an abundant quantity for all the purposes for which rainwater is usually required.

The reason for calculating that only half the actual rainfall is available for use is that there occur losses by absorption and evaporation, also by numerous light showers that yield nothing, or next to nothing, in the down-pipes; and, lastly, the fact that the first water—the washings of the roofs and gutters—should always be run to waste. A roof and its parts, especially when several days elapse between showers, become soiled by birds, while the gutters have a collection of insects and debris. This is undesirable matter to send into the rainwater tub or tank, and the purpose of the rainwater "separator" is to deal with this. The appliance is not a filter; it is a device by which the rain coming from the roof for about the first three to five minutes is run to waste, then its passage is automatically diverted to the storage tank.

Fig. 1 is an arrangement which can be made by anyone, and the whole of the operating parts are supposed to be against a wall. As indicated by the solid (unbroken) lines it may be supposed that the rainfall has just commenced, and the first water from the gutter is coming down the down-pipe shown into the pail. The pail is hung upon the end of the lower horizontal level shown, and as soon as the pail is full enough its weight will carry the end of the lever down, and this will act upon the rods above to make the down-pipe swing over, as shown by broken line. This piece of down-pipe must be free to move, as shown, and this is best arranged by nailing it by one ear only, the right-hand ear.

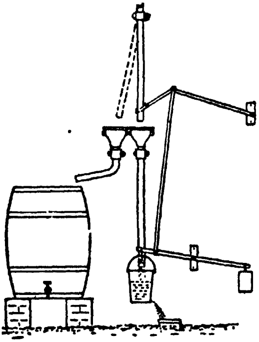

FIG. 1.

The pail requires to have a small hole in it near the bottom, little more than a pin hole, so that it will empty itself and then rise and straighten the down-pipe ready for the next shower. It does not matter if the pail is a long time emptying itself, for should another shower come before the pail has risen it would not matter, as a roof, once washed, may be reckoned to remain clean for several hours. The pail may empty itself into a gully, or into a large flower-pot sunk into the ground, or on to the ground, if the position is not an important one. The counter-balance weight can be of metal, or a stone, or a paint-can (with cover) partially filled with gravel.

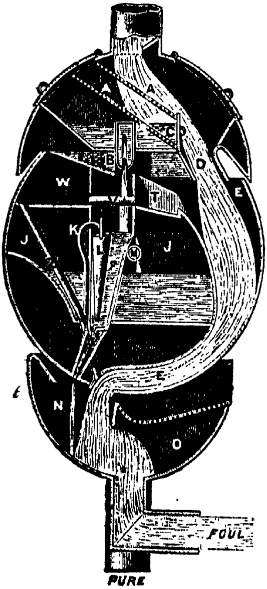

FIG. 2.

Figs. 2 and 3 illustrate Robert's rain-water separator (made in vertical form, as shown, or horizontal).* These illustrations show the separator with the front plates removed.

Fig. 2 shows it in the position that it retains when running foul water into the waste pipe during the first part of a shower, while the roof is yet dirty. Fig. 3 represents it when it has canted, and has begun to run pure water into the storage tank, after the roof has become clean. The change of position is effected by the gradual accumulation

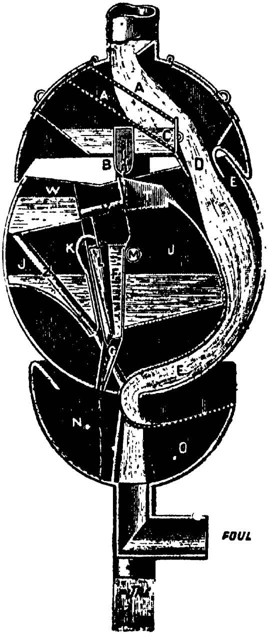

FIG. 3.

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* H. T. Rogers, Shotter Mill, Haslemere.

of a small portion of the water in the chamber J of the canter; when the water reaches a certain height, it makes the left side heavier than the right, and the canter turns a little on the pivot M that supports it, so that the water is delivered two inches further to the right than it was before; and whereas it at first ran through N into the waste pipe, it now runs through O into the storage tank.

In Figs. 2 and 3, AA are strainers removable for washing. B is a removable slide, with two small holes to regulate the flow of sufficient water to work the canter. C is a sluice to be adjusted to the area of the roof. D is the outlet for surplus water. In moderately heavy rain the main volume of the water flows through this spout D into the delivery pipe E, running round the right hand of the canter; a small proportion only passes through the strainer and out of the small holes B into the funnel F that terminates in the small hole G.

In a very slight rain the whole of the water passes through the strainers and the hole at B into F, and when it is not enough to effectually wash the roof it all escapes through G without making the canter move. When there is more rain than can pass through the hole G, it rises in F and L, and a small quantity runs over the side of the funnel, slowly filling the chamber J. When J is filled to a certain height, it over-balances the canter, and makes the water run to storage through O, as shown in Fig. 3. This change in position causes the water from B to run into T, and cease to run into F. As the water sinks in F it also sinks in L, causing the siphon K to act and empty the chamber J. Meanwhile the little chamber W is partially filled by water running through T, V, W and Z, and its weight prevents the separator from recanting until the water ceases to run from the roof.

As soon as W is empty, the canter rights itself, ready for the next rainfall, the right-hand side of the canter being heavier than the left when it is empty. By means of the joint action of the sluice C and the holes at B and G, the flow of water in the working part of the separator is so regulated that the chamber J is filled to the canting point as soon as a certain quantity of rain (a gallon, more or less, on each 100 sq. ft. of roof) has fallen, either quickly or slowly. Three slides, marked 1, 1½, and 2, are sent with each separator; if the destination of the separator is not known, the slide marked 1½ is usually put into its place at B, and the other two kept under the lid at the top. The one marked 1, intended for use in the country, allows about one gallon; and the one marked 2, for city use, allows about two gallons for washing each 100 sq. ft. of roof.

* * *

RAZOR PASTE.

Razor Paste.—(1) Mix fine emery intimately with fat and wax until the proper consistence is obtained in the paste, and then rub it well into the leather strap. Prepare the emery by pounding thoroughly in a mortar the coarse kind, throwing it into a large jug of water, and stirring well. Immediately the large particles have sunk, pour off into a shallow plate or basin, and let the water evaporate. This emery is better for engraving and other purposes than that prepared at the emery mills.

(2) Levigated oxide of tin (prepared putty powder), 1 oz.; powdered oxalic acid, ¼ oz.; powdered gum, 20 gr.; make into a stiff paste with water, and evenly and thinly spread it over the strop. With very little friction, this paste gives a fine edge to the razor, and its efficiency is still further increased by moistening it.

(3) Emery reduced to an impalpable powder, 2 parts; spermaceti ointment, 1 part; mix together, and rub it over the strop.

(4) Jewellers' rouge, black-lead, and suet, equal parts; mix.

(5) Flour emery, 2 oz.; neat'sfoot oil, 2 oz.; glycerine, 2 dr. Thoroughly rub together and pack into small boxes or tubes. It will keep a year.

(6) Diamond razor paste: tallow, 2 oz.; petroleum jelly, 5 oz.; coke, ground to flour, 2 oz. Rub into a paste and fill into tubes.

* * *

REFRIGERATION.

(*See also* DRYING AND DESICCATING, FREEZING MIXTURES, *and* PRESERVING AND PROTECTING FOODS, ETC.)

THE modern development of the anhydrous ammonia process (described below) has so completely simplified the industrial application of cold, that all older processes, such as were fully described in previous editions of "Workshop Receipts," are now of very little interest, since wherever power is obtainable, compact and inexpensive plants are in service, carrying out such work with a minimum of attention and at a very small cost, and fulfilling the requirements of the very smallest shops or industries.

There still remain, however, in use such methods as are described below for cooling and clearing the air, required in large buildings where ventilation is carried out by mechanical means.

Air Cooling Processes.—Fig. 4 shows what may be considered the latest practice adopted in cooling air by water, when as is the case in towns it is desired to filter the air at the same time. A suitable cellar or chamber is chosen for the outer air to first enter, the air coming through either simple holes or grated openings. It is important to see that this air proceeds from a sweet source, as the cooling or filtering process will not remove odours. It would not do, for instance, to have the supply of outer air come from a stable yard. Across the cellar near the middle, either direct across or at an angle, as may be best suited (the sketch shows the latter) is erected a coke screen as shown. This reaches the side walls, the floor and ceiling, so that no air can pass around it. There is from 8 in. to 12 in. thickness of coke, this being held by wire netting or lattice on each side. The coke is broken to 1 in. size and well washed before being filled in. At the top of this screen a space is left clear of coke and here are run two or three horizontal pipes pierced with small holes; and at one end, these pipes are joined to a cold water service (preferably a main service as having the coldest water in it) this service having a stop or control valve in it to regulate the quantity of water falling on to and percolating through the coke. At the base of the screen is made or cut a channel to take away the waste water. A side or cross section is as Fig. 5, and it will be noticed that where the water-pipes are, at top, the screen has solid sides, the netting commencing below this point. This is done to prevent air passing through above the coke.

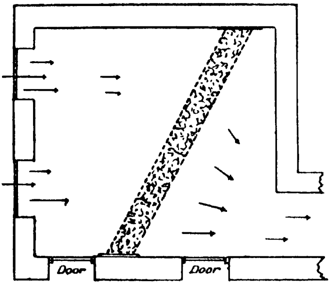


FIG. 4.

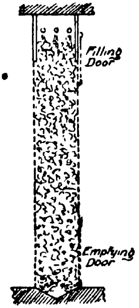


FIG. 5.

There is not the least doubt that a screen constructed on this principle is more effective as a cooling agent, and offers less resistance to the air, than a wet woven frabric; while the constant flow of water makes the screen self-cleansing.

Means adopted to induce the air movement are scarcely within the province of this article, but it may be stated that they are two, viz. a current induced by heated chimneys or ducts, or a current induced by a mechanically driven air propeller. It may also be added that this form of screen is used when buildings are warmed by heated air. The screen filters the air, and, in this case, provides or makes up the humidity that the air, after being heated, is in need of.

2. *By Evaporation of Liquids.*—(*a*) The evaporation and re-condensation of a liquid may be utilized in two ways for the production of cold. Typical of the first method is the well-known laboratory ammonia apparatus of Carré. This consists of two vessels, which may be called *a* and *b*, capable of resisting considerable pressure, and joined by a pipe. The first step in the process is the preparation of liquid ammonia. Vessel *a* contains a solution of ammonia in water, and is artificially heated; *b* is kept cool, and the air is effectually excluded, if there be any leakage, by a water jacket, and in it the ammonia condenses under the pressure caused by the heat of *a*. When sufficient ammonia is condensed, *a* is transferred to a vessel of cold water; the ammonia vapour is rapidly absorbed by the cold water within the vessel *a*. Under the reduced pressure in *b*, the ammonia boils, absorbing much heat and producing considerable cold. The second method is the exact converse of the condensing steam-engine. In the steam-engine, water is converted into steam in a vessel at a high temperature; it expands in the cylinder of the engine, losing a portion of its heat,

which becomes useful mechanical work; it then passes to a second vessel maintained at a lower temperature and pressure, in which it is condensed, giving up the balance of the heat it absorbed in the boiler. Imagine the water replaced by ether, the temperature of boiler and condenser appropriately lower, and the direction of rotation of the engine reversed by the application of external power, so that, in fact, it becomes a pump. The ether evaporates in the condenser, absorbing heat and causing cold; the ether steam passes to the pump, where it is compressed, converting mechanical power into heat, and, under the pressure exerted, it is condensed and forced at a higher temperature and pressure into the vessel corresponding with the steam boiler, where it gives up its heat as may be arranged. Upon the choice of the liquid used will depend the pressure and temperatures in the two vessels or chambers. At 32° F. (0° C.), the tension of water vapour is 4·6 *mm.* mercury; of ether, 183·3; of sulphurous anhydride, 1165·1; of ammonia, 3162·9. To produce 1 *litre* (1¾ pints) of water vapour at 32° F. (0° C.), require 0·0029 units of heat, the unit being the heat required to raise 1 *kilo.* (2·2 lb.) of water 1° C.; to produce 1 *litre* of ether vapour at the same temperature requires 0·073 units. At 32° F. (0° C.), each stroke of a pump will abstract by ether vapour nearly 30 times as much heat as by water vapour. A glance at these figures shows an obvious advantage in using liquids having low boiling-points; a pump of small capacity will remove a large quantity of heat, but all such substances are too costly to be wasted, and are offensive if any of the vapour escapes. Water presents obvious advantages, in the fact that we need not care what becomes of the vapour when condensed. But the use of water demands the power to produce and maintain a near approach to a perfect vacuum; the barometric pressure must be reduced from the normal of about 760 *mm.* of mercury, to less than 4, and for every unit of heat removed, at least 350 *litres* of vapour must be withdrawn and condensed. Water may be used in either of the methods already mentioned. It may be used in a manner exactly corresponding with Carré's ammonia apparatus, the water taking the place of the ammonia, and some hygroscopic substance, such as sulphuric acid, taking the place of the water, the pressures of course being always very much lower. Or if we can find a sufficiently perfect pump to produce and maintain a vacuum of less than 4 *mm.* of mercury, we may realise the precise reversal of the condensing steam-engine; but to produce any quantity of ice, the pump must not only be very perfect, but have a good capacity. A combination of the two methods answers best. (Dr. Hopkinson.)

Anhydrous Ammonia Principle.—It is claimed that some ninety per cent. of the practical and large freezing plants now in use are worked on this principle. The refrigerant possesses the important advantages of a low liquefying pressure and a high critical temperature, this latter property enabling it to be employed in hot climates where the temperature of the cooling water is more or less high.

A firm making a speciality of the complete apparatus required in this work is the Pulsometer Engineering Co. Ltd. of Reading and London, and the following matter is extracted from a very useful publication that can be had from them.

The apparatus employed is that required in what is known as the ammonia-compression principle. The chemical used is pure anhydrous ammonia (NH_3)—not Aqua Ammonia—which can be purchased in almost every part of the world. The use of this agent makes the apparatus easy to handle, while only requiring a moderate working pressure; and by using specially constructed fittings there is hardly any loss of ammonia.

The action of the machine is as

follows.—If liquid anhydrous ammonia, under pressure, be allowed to expand into a vessel (the refrigerator) the liquid becomes a gas and the pressure falls. This action produces intense cold, which may be used either for refrigerating or ice-making. If the ammonia gas be then compressed, and the heat, which is given off, removed by cooling it with water, it again becomes a liquid, and the operation continues as first described. The machine for compressing the gas is called the compressor, the apparatus for cooling the hot ammonia gas is called the condenser, and the vessel in which the cold is produced is called the refrigerator. The intensity of the cold is controlled by varying the expansion by means of a cock between the condenser and the refrigerator.

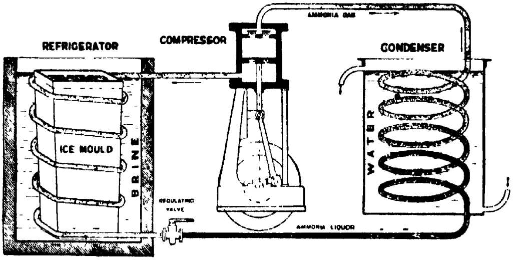


Fig. 6.

The compressing pump may be driven by any form of available motive power.

The condenser is formed of lengths of wrough-iron tubing, and is placed either in a tank and cooled with water—when it is called a submerged condenser—or it may have water trickled over it, in which case it is called an evaporative condenser.

The Refrigerator generally consists of wrought iron coils, and these are employed either submerged in brine (as for ice-making) or in water for water cooling, or they may be placed direct in a room to cool the air.

Fig. 6 will give a general idea of the action of the machine, and it will be seen that the system is simple and free from complications.

Before deciding on a plant, it is first necessary to determine the requirements, and to decide which of the following operations will meet the case :—Ice Making, Freezing, Chilling, Cold Storage of Goods, Cold Storage of Ice. Artificial ice can be produced in a variety of sizes and of two classes —either crystal or opaque.. One of the three following methods is usually adopted :—

Can Ice.—Opaque or Crystal.
Cell Ice.—Crystal.
Plate Ice.—Crystal.

Can Ice. — In this system (the cheapest) the water to be frozen is placed in metal moulds, made either of galvanised iron or leaded iron—the latter being cheaper but not so durable. When ordinary water is frozen in these moulds the ice produced is hard and opaque, but it is quite good enough where the ice is to be used only for cooling, such as fish preserving, ice creams, and ice boxes. Clear ice can also be made in cans.

The sizes of blocks manufactured in ice cans vary from 17 lb. to 200 lb.

Standard sizes, together with the average time taken to freeze one block, are given in the following table :—

Weight of Block.	Size of Can at Top.	Length.	Time of Freezing
lb.	in. in.	ft. in.	Hours.
17	7 × 3	2 6	3
56	7½ × 7½	3 7	12
50	22 × 3½	2 5	12
112	22 × 5	3 10½	24
200	22 × 8	3 10½	50
224	18 × 9	4 7	60

It will be seen from the above that the larger the block of ice required, the longer the time taken in freezing ; and consequently the initial first cost of the ice tank will be greater. This should be remembered when deciding upon an installation. The smaller the size of block, the cheaper the plant.

Clear Can Ice.—Clear ice can be made in moulds, by either : (1) Agitating the water (not distilled) during freezing ; (2) Using distilled water (made by condensing the exhaust steam from the engine) for filling the ice mould.

The first method is only used where it has been decided to use the can system, and where distilled water is unobtainable—for example, where gas or oil engines are used and there is no steam. Several plants have been supplied on this system with satisfactory results ; but where possible we prefer to use system 2, usually called "making ice from distilled water." The steam coming from the engine driving the compressor is condensed, then passed to a re-boiler, where all the gases and air contained in the water are expelled. The hot water is then conveyed to a cooler, where it is reduced as much as possible in temperature, and finally, after passing through a charcoal filter, is used for filling the moulds. With reasonable care in handling, the ice produced is clear, bright, transparent and perfectly pure and wholesome, and is sold for table use. Flowers, fish or game placed in the moulds before freezing can be frozen in, and show clearly through the ice when the block is formed. The first cost of this system is greater than when making opaque ice.

Cell Ice.—In this system, commonly called "Siddeley Cells," the ice tanks, which are generally made in units, to hold, when frozen, 5 or 6 tons, are made to turn out blocks of clear ice weighing either : 5 cwt., and measuring 12 in. by 30 in. by 48 in. ; or 6 cwt., and measuring 12 in. by 33 in. by 51 in. The tanks are made of wood, and are fitted with a series of longitudinal and transverse hollow brine cells of metal, through which cold brine is kept constantly circulated. The water to be frozen, which does not require to be distilled, is placed between these cells and is agitated during the process of freezing. The ice produced is beautifully clear, and has the advantage of being in large size blocks. By means of a special arrangement, hot brine can afterwards be circulated through the cells, thus thawing off the ice from the cells and enabling the ice to be lifted. On the average a 5-ton tank, making 5 cwt. blocks, takes four days to freeze up, so that for a plant turning out 5 tons of ice per 24 hours, four tanks would be required, and it is therefore usual when making ice on this system to arrange for a plant having an output a multiple of five, and also it will be seen that this system is not applicable to plants of less than 5 tons capacity. The first cost is very much higher than any of the foregoing, but it has the enormous advantage of producing very large, clear blocks of ice. The working expenses are about the same as for clear can ice.

Plate Ice.—This system produces the very best ice that can be manufactured, and is superior to the finest Norway ice ever imported. The blocks produced can be made up to 16 ft. by

8 ft. by 10 in. to 14 in. thick; no distillation is needed, ordinary water being used, the impurities falling to the bottom of the tank. The tanks, which are of wrought iron, are divided into compartments by hollow walls, and the ice is formed on these walls. Through these, cold brine is caused to circulate, and the water in between is kept moving by means of paddles, whereby all air is liberated and the impurities are thrown to the bottom of the tank.

To thaw the ice off, warm brine is circulated in the hollow walls, thus releasing the ice from the freezing plates. This system is only applicable to the larger size of plants, say from 12 tons upwards. The outlay and cost of production are about the same as for cell ice, and both classes possess the advantage, that, as distilled water is not required for their manufacture, the engine can be made condensing, and a corresponding economy in fuel effected.

Local conditions must, to a great extent, determine the class of ice to be made, the chief among them being the nature and quality of ice being made, or sold, in the district for which the plant is required.

For cooling purposes, only rough ice is required, and the cheapest way of producing this is in cans or moulds.

For immediate consumption small blocks are desirable; for long journeys, or where the ice is not required immediately, larger blocks are recommended—about 1¾ to 2 cwt.

For abroad, where clear ice is required in small quantities and where a steam engine cannot be used, moulds with agitating gear is the best system to adopt.

Chilling.—Cooling goods to a temperature not lower than 35° F. is termed chilling.

Freezing.—Cooling below the above temperature is termed freezing.

Cold Storage of Goods.—Cold storage of goods is the keeping of goods that have been either chilled or frozen. The best temperature for storage is determined by the class of produce (see page 13).

The degree of insulation (for preventing increase of temperature) should be determined by striking a balance between the interest on the first cost of insulation and the cost of keeping the store cool.. For example, with first-class insulation (which is expensive) the machine will only have to run, say, 12 hours out of the 24 hours; but with poor insulation the machine must run every hour in the 24; and if for any reason a stoppage occurs, the temperature rises, with the risk of spoiling the goods in the store.

Miscellaneous Methods. The following are the methods of cooling cold stores or refrigerating chambers, together with their advantages and disadvantages:—

(1) Brine pipes alone.
(2) Direct expansion ammonia pipes alone.
(3) Brine air cooler and air circulator.
(4) Direct expansion cooler and air circulator.
(5) Special accumulator system for small stores.

Brine Pipes Alone.—In this system wrought iron galvanised pipes, 2″ inside diameter, are placed on the ceiling of the store to be cooled, and are connected at the ends either by bends or headers. The pipes are filled with a solution of cold brine supplied from the refrigerator of the ice machine. The cold brine is circulated by means of a pump, and after passing through the pipes returns to the refrigerator to be again cooled. This system has been most successfully adopted, and is generally used either on board ship or in bacon factories. It has this advantage, that when the machine is stopped there is always a store of cold brine in the pipes, which will keep the room cool for a considerable time without running the machine. This, however, costs more than the direct expansion system, as a refrigerator is required in addition to the brine pipes. With the adoption of this method, it should be borne in mind that the brine pipes gradually become coated with frozen moisture, which has to be removed by passing hot brine through the pipes. This operation involves the stoppage of the cold room for a short period.

Direct Expansion, Ammonia Pipes Alone.—It is desirable in some cases, say as in lager beer fermenting rooms, to use direct expansion cooling pipes, and in this case heavy lap-welded pipes and coils are placed on the ceiling and ammonia expanded in them. This makes a sound substantial job when constructed with a system of wrought iron headers, this system being perfectly tight and free from leakage. Of course no other refrigerator is required beyond the expansion pipes. But the same trouble may be experienced as above, viz. :—That the pipes become coated with snow, and must be thawed off with hot ammonia. This system is, however, cheaper than No. 1, but has no reserve of cold, the cooling action ceasing with the stoppage of the compressor.

Brine Air Cooler and Circulator.—This system is undoubtedly the best, although the most expensive. Wrought iron galvanised tubes are arranged in a series of coils in a walled-off part of a store ; cold brine is circulated through these coils and the air of the rooms is circulated by means of a fan over these coils and through all the rooms. When the coils get snowed up, the fans are stopped, and cold brine is pumped over them, which entirely cleanses them, and, when clean, the fans are started again. The advantages are :—A clear, cold atmosphere ; a reserve of cold when the plant is stopped (the fan can be still kept running) ; entire safety as to the prevention of the brine used in cleansing being carried thorough the air ducts to provisions. The disadvantage is :—extra cost, due to extra refrigerator and brine pump.

Direct Expansion Cooler and Air Circulator.—This system is the one most generally adopted, and consists of a series of wrought iron coils placed in a walled-off portion of the cold stores. In these coils the ammonia is allowed to expand, thus producing cold. A fan or air propeller is used in connection with wooden air ducts for circulating a large volume of air over the cooler, and through the air ducts to any room. The warm air reaches the fan by air ducts from the various rooms, and, passing over the refrigerator, is cooled. By means of a centrifugal or sparge pump, a supply of brine continually circulates over the freezing coils, keeping them free from snow, and at the same time cleansing and drying the air. The atmosphere produced by this system is perfectly clear and dry, and the temperature can easily be regulated in any room by means of slides placed in the air ducts. This system is cheap in first cost, and, if thoroughly well looked after, is very good, but it must be borne in mind that the brine used for cleaning the cooling coils is liable to be carried along the air ducts and deposited on the meat, and further, when the plant is shut down there is no reserve of cold.

Accumulator System. — This is a special system designed for small stores for keeping meat and fish, and also to reduce the necessity of running day and night continuously and on Sundays. Briefly the system is this :

The store to be cooled is divided into two compartments, one for fish and one for meat. Above the fish store is placed a wrought iron tank filled with brine, and this tank is fitted with an expansion coil, forming the refrigerator. The exposed under-surface of the tank is sufficient to keep cool the fish store. The meat store is fitted with a series of brine coils kept suppled with cold brine from the refrigerator tank, by means of natural circulation, and is also fitted with a fan and air trunk for circulating, purifying and drying the air. These coils are kept clean by means of a small sparge pump.

When the machine is stopped, the large amount of cold stored up in the refrigerator tank keeps the fish store cool by means of its exposed underside, and keeps the meat store cool by the natural circulation in the cooling pipes placed in it. By this arrangement the fish is kept at a lower temperature than the meat.

This system is thoroughly efficient, and has given excellent results in practice.

Motive Power.—The question of motive power is an all-important matter for consideration, the objects to be kept in view being economy in fuel and maintenance, combined with a reasonable first cost and immunity from breakdown. Interest on first cost and depreciation must be considered simultaneously with economy in fuel, for if this latter be pushed too far, the saving in fuel will be more than absorbed by the former.

The usual sources of power are as follows :—*Coal, Gas, Oil, Electricity, and Water*. (The latter, which is cheapest, is so seldom available that it will not be considered here.) By reference to the table of H.P. required for various outputs, the following information will determine which is the cheapest form of motive power to employ (exclusive of first cost).

Coal.—2 lb. of coal are required to produce 1 indicated horse power for one hour with a compound *condensing* steam engine of a fair size.

2 to 2½ lb. will be required if the engine be *non-condensing*

4 to 5 lb. will be required for a *simple* high pressure steam engine.

These results may be considerably improved by the employment of high pressure superheated steam with or without triple expansion.

Gas.—15 cubic feet of gas are required for each horse-power hour.

Oil.—1 pint of crude oil is consumed for each horse-power hour.

Electricity.—Electricity is sold by the Board of Trade "Unit," varying in price from 2*d*. to 6*d*.

1 unit will produce about 1 horse-power hour.

Without knowing all the conditions for any particular job, it is impossible to advise as to the best form of power ; but the following information, in addition to what has been stated above, will be of assistance to the intending purchaser.

If clear ice is required by the condensed water method, it may be advisable to employ a compound non-condensing steam engine, using the exhaust steam for the clear ice making.

Where ice storage is in view, electricity is often the cheapest form of power, most electric supply companies being willing to grant very cheap rates for power during the day time (it is only for this period of the 24 hours that the storage of ice requires power).

A good water supply has an important bearing on the selection of motive power ; whether for condensing the steam from the engine or the ammonia in the ammonia condenser. Water always reduces the cost of running, and it may be further remarked that the cooler the water the smaller the plant for any given output.

POWER REQUIRED FOR ICE-MAKING.

Weight of ice made per 24 hours. Approximate horse-power required. (Effective.)

10 cwt.	18 cwt.	1¼ tons.	3 tons.	5 tons.
2¼ H.P.	4 H.P.	8 H.P.	12 H.P.	18 H.P.

10 tons.	15 tons.	20 tons.	25 tons.
25 H.P.	32 H.P.	42 H.P.	52 H.P.

If water is available at the mere cost of pumping, it is best to use condensing engines and submerged gas condensers, and possibly non-condensing engines. Plants have been arranged where the engine has been condensing and the ice has been made from the condensed exhaust of the engine, and this at a water consumption hardly exceeding the amount of water required for making the ice.

Chemicals.—The two chemicals used are chloride of calcium (the solution of which is commonly called chloride or brine) and anhydrous ammonia (NH_3), which is liquefied gas, not the ordinary aqueous solution known as liquor ammoniæ.

Brine.—This is the vehicle or medium for conveying or applying the cold produced by the expansion of ammonia in the refrigerating coils. It is a noncongealable solution, and is made by dissolving in water chloride of calcium, which is obtained in wrought iron drums. Ordinary salt can be used instead of calcium, but it is not to be recommended, on account of its deleterious effect on the coils and tanks.

SOLUTION OF CALCIUM CHLORIDE.

Percentage by Weight.	Specific Gravity at 60° F.	Specific Heat.	Freezing Point	
			Degrees F.	Degrees C.
1	1·009	·996	31	− 0·5
5	1·043	·961	27·5	− 2·5
10	1·087	·896	22	− 5·6
15	1·134	·860	15	− 9·6
20	1·182	·834	−5	−14·8
25	1·234	·790	−8	−22·1

The chloride of calcium should be mixed with the water in a separate tank, so that any impurities may float to the top and be removed from the brine before being used. The heavier deposit which will be found at the bottom of the tank must on no account be put into the circuit. After the plant has been put to work, it is well to test the brine occasionally to see if any ammonia is leaking into the brine. This may be ascertained by means of "Nessler's Reagent" (to be obtained at any chemist's).

Ammonia is the refrigerant or material which produces the cold; it is a very penetrating and searching gas, and unless the fittings through which it passes (such as valves, tees, pipes) are of wrought iron or steel, there will always be a leak sooner or later, with consequent loss of ammonia.

Ammonia Fittings.—With the employment of cast iron, it is impossible to secure absolute and continued immunity from leakage and its consequences. The excessive loss of ammonia in indifferently designed and cheaply made machines is not infrequently attributed to the decomposition of ammonia due to continuous working. That this is not the case is demonstrated by the fact that when proper fittings are used, little or no replenishing of ammonia is required. This is a most important fact.

Cost of Production.—The cost of producing varies between limits so wide, depending upon the conditions and type of plant, that it is not practicable to give exact figures, but we may say generally that with large plants the cost per ton of making ice is 1*s.* 9*d.* and upwards.

Ammonia rectifier and oil separator.—The object of the rectifier is to remove, from the ammonia circuit, oil, water, and any other impurities which are originally present in the ammonia, or which gradually find their way into it during the working. The apparatus is constructed so that it may be operated during the working of the plant. The diagram, Fig. 7, is self-explanatory, but a few words on the actual operation will not be out of place.

The receiver forms part of the gas circuit, and the whole of the ammonia passes through it, any water or oil being separated from the gas by the action of the internal "dash pipe."

The "purging" of the ammonia is carried out in the following way:—

Whilst the plant is running on its usual work, the cock A, between the receiver and the rectifier is opened. This will cause the pipe connecting them to become cold, and three minutes after this the cock should be closed, and the plant allowed to run on until the frost (which will gradually appear all over the receiver) has disappeared. The operation of opening and closing the cock should then be repeated until the receiver again begins to frost. It will be noticed that on this occasion the lower portion of the receiver will be black, due to the oil and impurities carried over in the first operation. The height of the black portion shows the amount of impurities carried over into the rectifier. The whole of the ammonia liquor is not usually carried over at the first or even second time, the operation must be repeated a number of times until all the liquor has been carried over, but not sufficient to fill the receiver more than three-quarters full. Sufficient time must elapse between the operations to allow the frost on the receiver to disappear. The point at which the frost commences and the black ends, is an indication of the quantity of liquor in the receiver, and when the bottle is three-quarters full and the frost disappeared (the cock A being closed), the rectifier should be brought to a temperature of 100° by placing a lamp underneath (in the tropics no artificial heat is necessary), and the liquor drawn off. If there is no weak liquor or oil in the machine, the rectifier will frost to the bottom at each alteration.

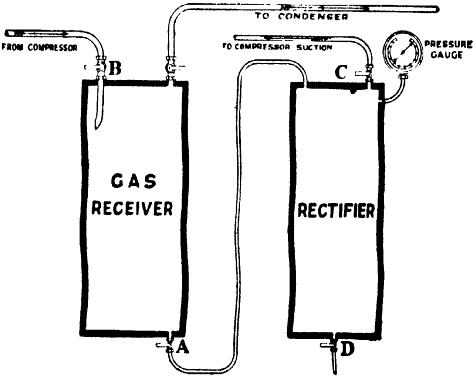


FIG 7

The oil drawn from the receiver may be used again after filtration.

TABLE OF TEMPERATURES FOR THE COLD STORAGE OF VARIOUS ARTICLES.

Article.	Deg. F.
Apples	33–36
Asparagus	35
Bananas	50–55
Beef (chilled)	33
Beer (in barrels)	33–40
,, (bottled)	45
Berries (fresh)	36–40
Butter	25–30
Cheese	32–33
Dates, Figs, etc.	55
Eggs	33–35
Fish (fresh)	25–30
,, (dried)	35

Article.	Deg. F.
Fruits (dried)	35-40
,, (canned)	35
Game (frozen)	25-28
,, (to freeze)	15-28
Honey	45
Lemons	36-40
Meats (fresh)	35
,, (canned)	35
Mutton (frozen)	18-20
Oranges	45-50
Peaches	45-55
Pears	35
Potatoes	36-40
Poultry (frozen)	28-30
,, (to freeze)	18-22
Rabbits (New Zealand frozen)	15
Sardines (canned)	35
Tomatoes	35
Vegetables	35-40
Water-melons	35
Wines	15-50

Insulation.—The purpose of this is to prevent increase of temperature from outside sources - to prevent loss of coldness, it might be said, though the introduction of warmth from any source or cause is what has to be guarded against. The materials commonly used are saw-dust, charcoal, or slag-wool, though any material that answers well as a non-conductor of heat will serve. Probably the best is slag-wool (silicate cotton) though it is not, of course, so cheap as saw-dust, cow-hair, and other organic materials.

Fig. 8 shows an example method of insulation. Very many methods can be adopted, depending on the structure of the room or building, but in this case it is supposed that the walls are of brickwork or concrete. A good coating of waterproof paint is first given to prevent moisture working through, then 6 by 2 in. upright battens are fixed, and on these come ¾-in. match-boarding. The boarding is commenced at the bottom, and as it rises the insulating material is packed in. Over the first boarding, when finished, is tacked a layer of waterproof paper, and on this follows another layer of boards arranged to "break-joint"; that is, the joints are arranged not to come directly over one another.

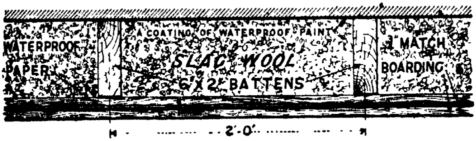


FIG. 8.

Ice Skating-Rinks.—The preceding matter devoted to ice-making explains practically everything that requires to be known for the making of an ice-rink. One of the largest establishments of this kind in London had for its freezing apparatus an ammonia compression machine, not of the make just described, but working on that principle. Its capacity was 12 tons per day, but one-third of this was not needed for the rink (this requiring refrigerating power equal to 8 tons), the balance of power being devoted to making block ice and maintaining cold storage chambers. The rink is made by forming a sunk waterproof floor, capable of taking about 6 in. depth of water. On this floor pipes are run to and fro as close as they can be got, i.e., with no more space between them than is necessary in making the sharp return bends in the pipes at the ends. The water to form the ice skating surface is run in and covers these pipes sufficiently to admit of the wear and tear of the skates, and to allow of the scraping or planing that the ice is subjected to about every hour or so when it is in use. About 2½ in. thickness of ice above the pipes is sufficient. The pipes are charged with the brine made of calcium chloride, already described, and this is kept circulating by a pump which is continually taking the brine through the refrigerator. The brine used is a strong solution, so that it can be cooled to some degrees below zero (F.) or say 35° to 40° below freezing-point, and needless to say, if the pipes in the rink are kept charged with this, the water surrounding and covering the pipes becomes a very firm ice.

Cooling Syrups, Solutions, etc.—The moderate cooling of fluids by the effect of a current of cold water is an essential condition of the condensers attached to stills, and this part of the subject will be found discussed under Distillation. Much the same principle is employed in refrigerators for cooling brewers' worts, the object being to attain the maximum exposure of the wort in the least possible time and space.

An equally important but far less developed application of cold to solutions is with a view to separating their valuable portion from the accompanying water. On this subject, Prof. Mills remarks that "theoretically it comes to much the same thing whether you get a substance separated out by means of heat or cold. Cooling is effected by a heat engine, but universally the nature of the substance must have a very material influence, and that alone may decide as to whether we ought to apply heat or cold in any particular case. Ellis has proved the economy in the application of cold in the case of soda sulphate, owing to the peculiar property it has of crystallising out in great abundance at low temperature. In this case, the mere application of heat raises no objection, because the sulphate is an object which you can treat as severely as you please by means of heat. This process, however, is very suggestive in other ways, for example, in dealing with organic bodies, which seem to be specially proper substances for this treatment. Again, in the preparation of solid paraffin wax from the blue oil, cold is constantly employed for the purpose ; in fact ever since the greater improvements in the paraffin oil manufacture have been made, this has been systematically applied in order to extract the paraffin. It is surprising that we have not heard more of cold in this way. Why should we not purify such a substance as carbolic acid by dissolving it into some suitable naphtha, and by means of cold separate it again? In this way we might find some means of preparing pure carbolic acid with greater rapidity. Again, polybasic acids might yield similar results. Why not try the effect of cooling solutions of benzoates and tartrates?"

More than 30 years ago, Kneller proposed to concentrate syrups by forcing cold air through them, and his plan was much improved by Chevallier. Sugar made in Chevallier's apparatus rivalled that of the vacuum-pan in every respect. A vessel holding 200 gal. of syrup (composed of 3 parts sugar to 1 of water) is estimated by Wray to turn out 12 tons of sugar daily. The cost of the apparatus is small ; the power required is trifling ; the ordinary air of the estate could be used in dry weather, and would entail an insignificant expense for drying in damp weather ; and the quality of the sugar is unsurpassed. In 1865, Alvaro Reynoso proposed to rapidly cool the syrup in suitable machines, and thus form a confused mass of particles of frozen water (ice) and dense syrup. The mixture is afterwards separated in centrifugals, and the syrup, deprived of ice, is evaporated *in vacuo* ready for crystallisation. It seems most singular that, in the face of the many drawbacks and great cost incurred by concentration by heat, so little effort is made by sugar-growers to adapt the cooling system to their needs.

Ellis ('Jl. Soc. Chem. Ind.') has published the results of his experience in the application of cooling to the recovery of soda sulphate from waste liquors. He found that 100 parts of water at 91° F. can hold in solution 412 parts of soda sulphate crystals ($Na_2SO_4+10H_2O$); at 86° F., 184 parts; at 79° F., 110 parts; at 77° F., 98 parts; at 68° F., 58 parts; at 50° F., 23 parts; and at freezing-point only 12 parts; so that a very slight lowering of temperature in the case of a strong solution gives a very considerable yield of crystals; a solution saturated at 94° F. should yield almost 97 per cent. of the crystals if cooled to 32° F. The waste liquor experimented on was about equivalent to a solution saturated at 65° F., and on cooling it down to 40° F., about 2·5 lb. of the salt were always obtained from 1 gal. of liquor; this salt was tolerably pure, and by washing it with a spray of saturated solution of soda sulphate, a salt almost free from foreign bodies was obtained. Some samples which were analysed contained about 0·2 per cent. of common salt and 0·04 per cent. of iron. The next point to be considered is how much heat requires to be abstracted from 1 gal. of the liquor at 65° F. in order to reduce its temperature to 40° F. and to obtain the crystals from it. We will take as our thermal unit the quantity of heat required to raise 1 lb. of water through 1° F.; 1 gal. of the liquor weighs about 12.5 lb. and has a specific heat of about 0·85, so that 12·5 × 0·85 × 25 = 265·6 thermal units must be extracted in addition to that which is given out by 2·5 lb. of salt while crystallising: this may be taken at 250 thermal units, giving a total of 515·6, to obtain 2·5 lb. of the salt. About 10 times this quantity of heat would require to be supplied to the liquor in order to get the same amount of the salt by evaporating it to dryness. In order to arrive at an idea of the cost of abstracting heat from a solution by artificial means, Ellis consulted Coleman of the Bell-Coleman Refrigerating Company, and he stated that one of his refrigerators which consumed 5 tons of coal in 24 hours could in that time produce cold capable of abstracting 4,000,000 of the above thermal units, which is just about $\frac{1}{10}$ of the corresponding heat which the same weight of coal can supply in practice when applied to evaporation. However, in the case under consideration it would be quite unnecessary to make use of artificial cold for the whole of the reduction of temperature from 65° F. to 40° F., as during a considerable portion of the year, at least half this cooling could be brought about by natural means, and as the yield of crystals is proportionately much greater between 65° F. and 50° F. than between 50° F. and 40° F. it might be found more advantageous not to attempt cooling below 50° F. at all. The liquor contains about 53 parts of salt to 100 parts of water, and by cooling to 50° F. 30 of those parts should be recovered, whereas further cooling to 40° F. would only yield 6–7 parts more of crystals. Ellis was at first inclined to think that the question of the recovery of the salt, economically, could be solved by the use of artificial cold, produced by a mechanical refrigerator of such form as the Bell-Coleman Co. make, but on going into details of cost and working expenses, he feels almost convinced that a similar result could be brought about in another way much more economically, and he proposed the following method for the treatment of this liquor on the large scale. Let us first take a case when the atmospheric temperature is about 50° F. or lower. The liquor could be run away from the precipitating tanks in the copper works into a reservoir of suitable dimensions, where it would be allowed to remain some little time to permit of the solid impurities settling out, and also to allow the liquor to cool down to a certain extent. It could then be made to flow slowly and continuously along a shallow shoot, on the outside of which a current of cooling water ran in the opposite direction to the flow of liquor. In this way all the cooling effect of the water would be utilised, and the liquor would flow away at the end farthest from the reservoir at a temperature the same, or nearly so, as the cooling water, leaving behind it in the shoot all the soda sulphate crystals, which it was unable to hold in solution at that temperature. These could be fished out from time to time without stopping the flow of fresh quantities of liquor, and at once taken to a hydro-extractor, where they could be washed with a spray of saturated solution of soda sulphate, and dried. In this way they would be rendered almost entirely free from foreign bodies, and could then be furnaced and converted into salt cake. This direct treatment could of course only be used when the temperature of the air and water was not much above 50° F., if a fair percentage of the crystals in the liquor were to be recovered, but as this temperature is considerably below the average for a great part of the year, the liquor would require at other times to undergo treatment before entering the reservoir, so that after such treatment it would be of a strength to yield per gallon at the particular temperature, as much soda sulphate crystals as a gallon of the original liquor would yield at 50° F. This could of course be brought about by a partial evaporation. Let us suppose, for instance, that the temperature was at 59° F., and that the liquor was of such strength as to be capable of yielding at 50° F. 2 lb. of crystals from the gallon. From the table of solubilities at different temperatures, it is easily calculated that by evaporating away about 20 per cent. of the water from the liquor, or about 1·4 lb. per gal., a liquor would be obtained which would give per gallon the same yield at 59° F. as 1 gal. of the original liquor would give at 50° F., or if the temperature were as high as 68° F. an evaporation of 40 per cent. or about 2·8 lb. per gal., would again give a liquor which would yield the same result. Thus by varying the amount of evaporation according to the temperature of the air and the yield of salt required, any required result could be arrived at, the limit of course being where the evaporation was carried to the extent of driving off all the water and leaving the dry salts. This was the case in the method of treatment which was formerly resorted to, and which, from the above, appears to be an expensive and, except in most exceptional circumstances, a useless method of procedure, for, by the method of cooling after partial evaporation, when the temperature is at 59° F. only 1·4 lb. of water requires to be evaporated away in order to get 1·76 lb. of salt (that is 2 lb. less 12 per cent. for reduction in bulk of the liquor during the partial evaporation) in a fairly pure form, whereas by total evaporation, that is, driving off about 7 lb. of water, only 3·75 lb. of a very impure salt is the result, or a little over twice the quantity of salt for 5 times the evaporation. Having evaporated the liquor in part, it could be run into the reservoir and be put through the same treatment as before stated. If the liquor were run from the reservoir at a temperature 30° F. above that of the cooling water, theoretically there would be required less than twice as much cooling water as liquor to be treated, for from 1 gal. of liquor weighing 12·5 lb., $0·85 \times 12·5 \times 30 = 318·75$ thermal units would have to be abstracted in addition to 200 thermal units for the 2 lb. of salt while crystallising out, and 2 gal. of water should be capable of abstracting 600 thermal units, though, of course, in practice, rather more than the theoretical quantity of cooling water would be required. If it is required that only a given quantity of salt is to be allowed to run away in the final waste liquor for each gallon of the original liquor, and we suppose that that quantity is fixed at what would remain in solution after cooling the original liquor to 50° F.; when the temperature is at 59° F., in place of having to evaporate away 1·4 lb. per gal. we should have to drive off 2·5 lb. of water. Taking into consideration, however, that the liquor is a waste product of practically no value, this latter would not be such an economical way of working as the former, where a gallon of the partially evaporated liquor gave the same yield of salt as a gallon of the original liquor.

The plant required for working up this waste product in this way would be somewhat as follows: Piping to run the waste liquor to an evaporating pan from the precipitating tanks in the copper works, an evaporating pan (one similar to those used in the evaporation of brine would be suitable), a reservoir, a cooling shoot, a small tank for making saturated solution of soda sulphate, a hydro-extractor for drying and washing the crystals in, with small gas engine to work the same, a furnace for driving off the water of crystallisation and converting the crystals into salt cake, and piping to run away the waste liquor when it left the cooling shoot, and to conduct the cooling water away to be used for any further purpose to which it might be applicable. Ellis concludes with a rough estimate of the cost of working per day of 24 hours, on the supposition that 20,000 gal. were to be treated in that time, and that the average temperature throughout the year is 59° F. For the partial evaporation, about 2 tons of coal would be required at 7*s.* per ton; say 60,000 gal. of cooling water at 4*d.* per thousand; 4 men at 4*s.* and 4 boys at 2*s.*, to attend to the washing and furnacing of the crystals, etc.; gas for the gas engine, etc., 4*s.*; rent of ground, 5*s.*; management, 15*s.*; interest and depreciation on plant at 15 per cent. say on 2000*l.*, taking 300 working days per annum, 1*l.*; giving a total of 7*l.* The production of salt cake for this, taken at about 2 lb. of crystals per gallon, from about 17,000 gal. (after allowing for evaporation), should be over 7 tons, making its cost per ton about 1*l.*

ROPE-MAKING BY HAND.

(*See also* TYING AND SPLICING, *and* WIRE ROPES.)

Materials.—A rope consists of a number of threads of hemp, or other fibre, twisted together by means of a wheel, thus forming a closely assembled and strong cord. The term rope is applied to cordage above 1 in. in circumference and made of hemp spun into yarns, and a number of these twisted together form a strand. Three of these strands twisted or laid together is termed a hawser-laid rope, and 9 of them a cable-laid rope. When the rope is made very thick, it is called a cable, and when less than 1 in. circumference, a cord. Many kinds of fibre have been used for rope making, such as hemp and flax, tough grass, the husk of the coco-nut, the fibres of the wild banana, etc., and animal substances have been also used, such as strips of oxhide, horse hair and wool, and of later years, iron and steel wires have been twisted and plaited into cords and ropes of great strength for various purposes.

The superiority of the fibres of hemp to those of most plants has caused them to be chiefly used in the manufacture of cables, ropes, cords, canvas, and sail-cloth. In forming a rope, the fibres are first spun into yarns, the yarns into strands, the strands into a rope, and the ropes into a cable. The shortness of the hempen fibres (about 3½ ft. being the average length), requires this complex arrangement. If they were long enough to form a rope, the most advantageous method of using them would be to lay the fibres side by side, and to secure them at the two ends. Each fibre would then bear its own share of the strain, and the strength of the bundle would be that of the sum of the strengths of the separate fibres. As a long rope could not be formed in this way, the ends of the fibres are secured by twisting so as to produce sufficient compression to prevent the fibres from sliding upon each other when a strain is applied; but in attaining this amount of compression by means of twist, the strength of the fibres is greatly deteriorated; this very compression acts as a constant strain on the strength of the fibre, and must be deducted therefrom before the available strength can be applied. Réaumur found that a small well-made hempen cord broke in different places with 58, 63, 67, and 72 lb., its mean breaking weight being 65 lb.; while the 3 strands of which it was composed bore 29½, 33½, and 35 lb. respectively; so that the united absolute strength of the strands was 98 lb., although the average real strength of the rope was only 65 lb., the loss of strength being due to the twisting. More recent experiments by Sir Charles Knowles give a nearly equal loss of strength by twisting. He found that a white rope of 3⅕ in. circumference broke on an average of several trials with 4552 lb.; while the aggregate strength of its yarns, 72 in number, was 6480 lb. (each yarn bearing about 90 lb.); thus the loss was 1928 lb. or about 30 per cent. The strength of ropes can be calculated by the following rule: Multiply the circumference of the rope in inches by itself, and the fifth part of the product will express the number of tons the rope will carry. Thus, if a rope be 5 in. in circumference, 5 × 5 = 25, the fifth of which is 5.

The weakening effect produced by twisting varies considerably in the fibres of the same rope according to their distance from the centre or heart of the bundle. If a certain amount of twist be given to a bundle of fibres, the outer fibres, occupying more space than the inner ones, will be strained more, and will act with less useful effect than the inner ones, which will have to bear the greater part of the strain while the rope is being used. It is for this reason the hemp is first twisted into slender yarns, and a number of yarns into strands, and 3 of these into a rope, the strain being equalised, and the important properties of length and strength secured without too great a sacrifice of the strength of the individual fibres. Moreover, a rope could not be at once formed by twisting a bundle of fibres together, as when left to itself it would immediately begin to untwist. The strands are therefore laid in such a way that the tendency to untwist in one part shall counteract that tendency in another. Duhamel has endeavoured to ascertain the amount of twist that would produce the most useful effect. He made some ropes in which only one fourth the length of the yarns was absorbed in twisting instead of the usual proportion of one-third. These ropes when used in shipping were found to be lighter, thinner and more pliant than those in ordinary use. Ropes made of the same hemp and the same weight per fathom, but twisted respectively to ⅔, ¾, and ⅘, of their component yarns, supported the following weights in two experiments:

⅔ . .	4098 lb.	4250 lb.
¾ . .	4850 ,,	6753 ,,
⅘ . .	6205 ,,	7397 ,,

The result of these experiments led Duhamel to make ropes without twist by placing the yarns together and wrapping them round to keep them together. The rope had great strength but not much durability on account of the outer covering soon wearing away or opening at bendings, and thus admitting water, causing the yarns to rot. These selvedges or skeins of rope yarns are, however, used for tackle where great strength and pliancy are required.

Preparing the Yarn.—Before spinning the hemp into yarn it is heckled or hackled for the purpose of separating and straightening the fibres. The heckle is formed of a number of straight steel prongs set in a board with the points upwards; they are of various sizes: the smaller heckles strip the hemp of its short fibres or tow, when the hemp is said to be cropped, and is used for fine work, or for spinning below the usual grist, as it is called, the usual grist being a rope 3 in. in circumference, with 20 yarns in each strand. In the process of heckling, a quantity of hemp sufficient for spinning into one yarn 160 fathoms long is first weighed out, and the heckler, holding the fibres at one end, throws the bundle loosely over the points, and pulls it gently towards him: a number of fibres is retained in the heckle, and by repeating the process they are all retained. He then lifts up the whole bundle, and passes again through the heckle, the operation being assisted by the application of a small quantity of whale oil to the points. The fibres, thus separated, and made tolerably parallel, are tied up into a bundle called a tow of hemp, weighing about 3½ lb. Heckling greatly improves the appearance of the hemp, converting the hard knotted mass into a loose silky skein.

Spinning.—The fibres are spun into yarn in a long rope-walk of 600 or 1200 ft., one end of which is called the head, or fore-end, and the other the foot, or back-end. At one end is a spinning-machine, Fig. 9, consisting of two upright posts with a wheel between them, the band of which passes over several rollers or wheels, Fig. 10, turning on pivots in brass holes, the pivots projecting and terminating in small hooks, so that by turning the wheel the hooks are made to revolve rapidly. Posts are arranged at equal distances on each side the walk, and between every pair of posts a rafter is extended across; hooks are driven into this rafter for the purpose of supporting the yarns as they are spun.

The number of whirls in the spinning machine (generally about 12) determines the number of spinners that can work together. Each spinner wraps round his body a bundle of hemp sufficient for the spinning of one thread of yarn, taking care that the bight or double of the fibres is in front, the two ends passing behind his back. He draws out from the face of the bundle as many fibres as the size of the yarn requires, and, twisting them between his fingers, attaches the bight to one of the whirl-hooks, while the wheel, being turned by an assistant, gives the twist or turn to the fibres. The spinner holds in his right hand a piece of thick woollen cloth, with this cloth he grasps the fibres as they are drawn out, and presses them firmly between his two middle fingers, walking backwards all the time from the head to the foot of the walk, occasionally making a signal with his left hand to the wheel-man to turn fast or slow as may be required. He regulates the supply of fibres with his left hand so as to make the yarn of equal size, drawing back some if they enter his right hand in too great a number, and putting forward more if the supply is not sufficient. He does not allow the ends of the fibre to come near together, but distributes them in a kind of flat skein, so that the yarn may have a uniform strength throughout. The thickness of the yarn depends on the quantity of hemp which passes through the spinner's hands in a given time.

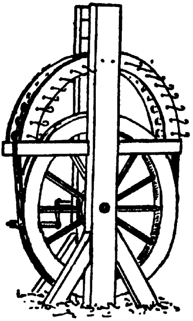


FIG. 9.

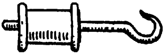


FIG. 10.

and on the rapidity with which the hook is made to turn. The spinner walks backwards at the rate of about two miles an hour, and as the yarn increases in length, he throws it over the hooks on the under side of the rafters, which are placed 5 fathoms apart. When the spinner has got to the lower end of the walk, and his length of yarn is sufficient, it is detached from the wheel and fastened to a reel, the spinner holding the end of his yarn (for if let go it would untwist) and as the reeler turns the reel the spinner walks slowly in, keeping the yarn equally tight all the way.

A good workman will in one day spin 8 quarters, or 48 yarns, each yarn 160 fathoms in length; and as the spinner has to traverse the whole length of the walk twice for every yarn, once in spinning it out, and back again in reeling it in, he has thus to walk nearly 18 miles in the course of one day's work.

Rope yarns are commonly from $\frac{1}{12}$ to rather over $\frac{1}{8}$ in. in diameter, and 160 fathoms of white, or untarred yarn, weigh from $2\frac{1}{2}$ to 4 lb.

When a number of spinners are working from the same wheel, each fastens his thread to a whirl, and they all proceed together down the walk; each man throwing his yarn on one of the hooks of each rail as he passes it. When they arrive at the foot, they join the ends of every pair of yarns and hang them over the posts; and in order to be able to separate them, a piece of twine is tied by the middle to the first pair a little in advance of the post; the second pair is then put over the post, and a string is tied over them, and in this way every pair is tied in. This is called nettling. The spinners now set-on at the foot or back-end wheel, and spin up the walk. The forward wheel-man having unhooked the yarns from the whirls of his wheel, and hung them over the posts, and tied them in pairs at the back-end, proceeds down the walk collecting the yarns from the hooks.

If the cordage is to be tarred, the process of tarring the yarns is now introduced. Tarred cordage is considerably weaker than untarred, but it is better calculated to resist wet. It loses its strength gradually in cold countries, and rapidly in hot climates. According to Duhamel, untarred ropes sustained a greater weight by nearly 30 per cent. than tarred ropes; and he states that white cordage, in constant use, is one-third more durable than tarred, that it retains its strength much longer when kept in store, and resists the action of the weather one-fourth longer. Cordage when only tarred on the surface is said to be stronger than when tarred throughout. Messrs. Chapman, of Newcastle, have stated that the rapid decay of tarred cordage is due to the presence of the mucilage and of the acid of the tar, which they propose to remove by boiling the tar with water and concentrating the washed tar by heat until it becomes pitchy, restoring its plasticity before use by the admixture of tallow or oils.

Preparatory to tarring, the yarns are warped into a haul; that is, they are unwound from the reel or roller, and stretched straight and parallel, when 300 or 400 yarns are assembled in a large group or haul, about 100 yd. long. This haul is dipped into tar heated to about 212° F. in a copper or tar-kettle, and is then dragged through a hole, called a grip, or gauge, or sliding-nipper, which presses the tar into the yarn, and removes the superfluous portion. The tar must not be too hot, or the yarns will be charred; nor too cold, or they will be black; they ought to be of a bright brown colour. The proper temperature is judged of by the closing in of a scum over the surface of the tar.

Laying into Strands.—The yarns either tarred or untarred are next twisted or *laid* into strands, the twist of the strand being in an opposite direction to that of the yarns, in order to counteract the tendency of the separate yarns to untwist, and that the yarns in their turn may counteract the tendency of the strand to untwist. The laying walk may be under the same roof as the spinning walk. It is provided with tackle-boards and wheels for twisting the strands, and stakes and stake-heads for supporting them. The tackle-board, Fig. 11, for twisting large strands is fixed at the head of the walk; it consists of strong upright posts supporting a plank pierced with holes which correspond to the number of strands, generally three, of which each rope consists. Winches or forelock hooks work through these holes. One of the smaller wheels for laying the smaller strands is shown in Fig. 12; it is supported on a strong post at the heads of the walk: the axes of the pinions are prolonged into hooks, and the driving wheel is worked by a winch. The strands are supported by beams or stake-heads placed at intervals along the walk; each stake-head, Fig. 13, contains a number of upright pins, between which the strands are placed. The yarns, as they are run out for laying, are first secured to posts at the head and foot of the walk, and as they become shortened by being twisted into strands, they are afterwards attached to movable sledges, Fig. 14, situated at the foot of the walk. The upper part of the sledge, called the breast-board, corresponds to the tackle-board, Fig. 11. The sledge is loaded with press-barrels, i.e. old tar-barrels filled with clay, for keeping it steady, and iron weights are also used for the purpose.

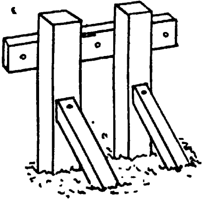


FIG. 11.

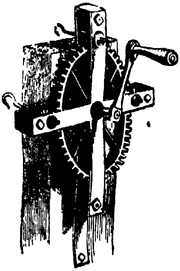


FIG. 12.

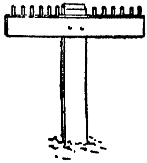


FIG. 13.

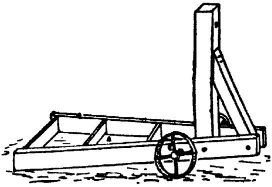


FIG. 14.

Supposing now that the yarn is properly warped for laying into strands, it is run out along the bearers of the laying walk, and the number of yarns required for the rope is counted, and divided into three separate portions, each portion being placed in one of the divisions of the bearers, and hung upon the hooks of the tackle-board and sledge. The sledge is pulled backwards to stretch the yarns tight, and the press barrels are put on. The yarns are now examined to see that they are of equal length and properly stretched; the hooks at each end are now heaved round in a contrary direction to the twist of the yarn, and in this way the three bundles of yarn are formed into three strands. By the consequent shortening of the yarns the sledge is drawn forward some way up the walk. When the strand is full-hard, or has enough hard in it, as it is termed, the twisting is discontinued; the sledge is moved forward to slacken the strands, and to allow of their being taken off the hooks.

The three strands thus formed are laid or twisted together into a rope; for which purpose they are attached to the middle hook of the tackle-board, and then placed in the grooves of a conical block of wood, Fig. 15, called a top, through which passes a pin for the handles or woolders as they are called. A piece of soft rope called a tail is attached to each woolder by its bight in the middle, while the ends are used to secure the rope in laying the strands. Tops of various sizes are used, and when a top is of very large size it is supported on a sledge. Now the three strands being attached to a hook of the breast-board, and then continued along the grooves of the top as in Fig. 16, the top is forced back as near the hook of the sledge as possible, and the men at the head again turn their hooks in the same direction as before. As soon as the sledge begins to move forward, the men diminish the load on the sledge, and turn the hook in a direction contrary to the former, by which means the top is forced forward; the three strands closing behind it as in Fig. 17 form the rope. The reason for turning the single hook containing the ends of the three strands in a contrary direction to the three hooks to which the other extremities of the strands are attached is to regulate the progress of the twists of the strands round their common axis, that the three strands may receive separately at their opposite ends just as much twist as is taken out of them in consequence of their being twisted the contrary way in being laid together. When the top is some way off from the sledge the tails are wrapped round the rope, and they by their friction prevent the top from moving by jerks and also enable the rope to close better. In this way a rope is formed by twisting three strands together. It will be seen that the strands unite into a rope on one side of the top and are kept separate on the other side, and that as the rope is formed the top is gradually driven forwards. The motion of the top requires to be regulated so as to ensure equal hardness in the rope: the top-man, therefore, before putting in the top, makes a mark across the strands of every beam: if, when the top reaches a beam, the mark be above the bearer, the top-man knows that the turning at the foretop has been too fast; if the mark be below, he knows that the turning has been too slow.

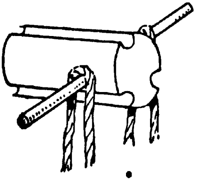


FIG. 15.

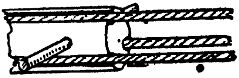


FIG. 16.

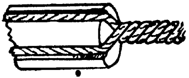


FIG. 17.

In laying a very thick rope, the men may not be able to turn the hook of the sledge to which the strands are attached; but they are assisted by other men, who apply woolders at intervals between the sledge and the top: the strap of each woolder is wrapped round the rope, and the pin is used as a lever to heave round the twist. The men at the woolders keep time in heaving with the men at the hook of the sledge; and in the case of heavy ropes the top sledge is used to support the rope.

In laying the strands it is necessary to vary the pressure at different parts of the process, and also the angle at which yarns take their position in the strands; the angle which the strands assume in forming a cable also require attention. In making a cable of 100 fathoms, for example, the length of the strands should be 152 fathoms, and should be laid at an angle of 27°; hard is given until each strand is shortened the length of 10 fathoms, when the angle must be 37°. In making the strands the sledge travels 24 fathoms, and the angle then made should be 32°. In laying the cable, the length of the strands thus formed amounts to 118 fathoms, and the angle when hard should be 40°. The length of the cable when finished is generally 101 fathoms; the strands entering with an angle of 35° while laying, and finishing at one of 38°.

With regard to the press-weights on the sledge: those for the strands of a 12-inch cable begin at 60 cwt., and when the length of 5 fathoms is attained, 10 cwt. is subtracted, and at 7½ fathoms another 10 cwt. is removed; so that the press, when the strand is hard, is 40 cwt.: but if it lays well another 10 cwt. is removed for the remaining distance. In laying the cable, the press begins at 160 cwt. this is reduced 10 cwt. at 1½ fathom; another 10 cwt. is taken off at 2 fathoms, and when the cable is observed to lay well, another 10 cwt. is removed, leaving a press of 130 cwt. for the rest of the cable.

The twisting of three strands together in the manner described forms what is called a hawser-laid rope: this is called the first lay. The second lay is formed with four strands, producing what is called a shroud hawser-laid rope. The four strands are laid in the same way as the three, and under the same conditions; but in order to render the rope solid a core-piece, consisting of a few yarns, is run through the centre. The third lay, or cable-laid rope, consists of three hawser-laid ropes, each formed of three large strands, twisted or laid together into one gigantic rope or cable. This, however, is now seldom made, the chain-cable having taken its place; but as cable-laid ropes are very hard and compact, ropes of no very great size are made in this way, if intended to resist the action of water.

Where great pliability is required, ropes are formed by plaiting instead of twisting; as for clock-lines, sash-lines, and generally where ropes have to pass over small pullies.

Flat ropes, used for mining purposes, are formed of two or more small ropes placed side by side and united by sewing, lapping, or intertwining with thread or smaller ropes. Flat ropes are also formed by similarly uniting a number of strands of shroud-laid rope. In either case the component ropes or strands must be alternately of a right-hand and a left-hand twist, or the rope would not remain at rest.

The Weight of Cordage may be calculated by the following rules:—

For shroud or hawser-laid rope, multiply the circumference in inches by itself; then multiply the product by the length of the rope in fathoms, and divide by 420, the product will be the weight in cwt.

For cable-laid cordage, multiply its circumference in inches by itself, and divide by four. The product will be the weight in cwt. of a cable 120 fathoms long, from which the weight of any other length may be deducted.

Care of New Rope.—New ropes are bad to deal with at first, owing to their tendency to twist, or, perhaps we should say untwist, or unlay. It

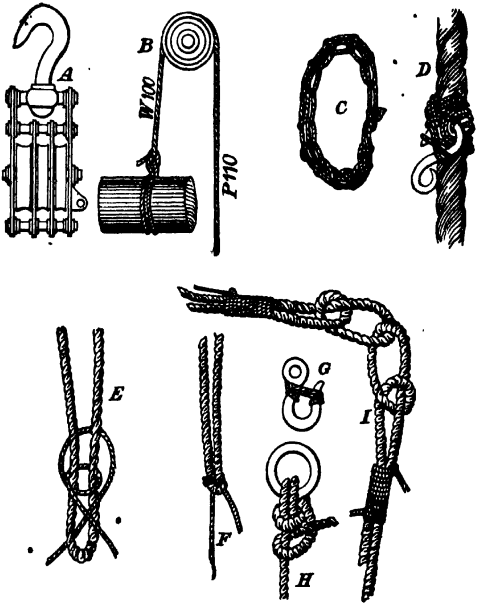


FIG. 18.

is difficult to uncoil a coil of rope without getting it full of "kinks." When practicable the coil of rope should be placed on a roller, and the end walked away with. Ropes intended for reeving "tackles" should be well stretched first. In order to do this, lay the rope out to its full length; connect one end to the barrel of a winch, and the other end to a holdfast, with a swivel-eye to admit of the rope unlaying itself. As the winch is worked and the rope made taut, it will begin to unlay; continue the strain up to the "working strength" of the rope, according to the following table of "working strengths," when it may be left taut for an hour, and then reeved. Ropes used with a thimble eye are safer than when ropes are slung over

TABLE OF HAWSER LAID CORDAGE.

Circumference.	Safe Working Load in Tons.	
In.	New.	Worn.
4½	2 6/7	2½
4	2 2/7	2
3½	1 5/7	1½
3	1 2/7	1¼
2½	6/7	¾
2	4/7	½
1½	2/7	¼
1	1/7	⅛

hooks, or fastened by knots. The hook of a block will soon destroy a rope under great pressure. It is true economy to use eyes where possible and convenient. In addition to the "knots" given under "Tying and Splicing," the following will be found useful in connection with blocks. C (Fig. 18) shows a "selvagee" formed of returns of spun yarn in a circle bound together. They are used principally for attaching the hook of a tackle, the "selvagee" being passed round the object and hooked into the tackle. To make a "selvagee," place two pins at a distance from each other, equal to the intended length of the "selvagee;" wind returns of spun yarn round the pickets until the "selvagee" is thick enough; then bind them together by half-hitches, with the running end at a distance of 1½ in. apart.

D shows the application to a rope. Lay the middle part of the "selvagee" over the rope, then bring both bights under and around the rope in opposite directions, until the bights are close, then place the hook in both bights.

E shows a double bend, useful for bending a small rope on to a larger one; it will be noticed that the smaller rope is passed twice round the larger one. In F the bend is drawn taut.

G shows a block hook, with a few turns of spun yarn taken round in order to prevent its clearing itself when hooked to anything, and is termed "mousing" a hook.

H is a fisherman's bend. Two complete turns are taken round the ring, or other object, through the two turns next to the ring, over its own standing part, thus forming one half-hitch; the second half-hitch is taken round the standing part alone.

I is a rolling bend. To make it, take a half-hitch with the running end round the standing part, lash them together just beyond the hitch, and size the end to the standing part; each part is exactly alike. It is sometimes called a "hawser bend."

RUBBER STAMPS, RUBBER TYPE AND RUBBER-STAMP INK.

(*See also* INKS.)

THE matter or letters to be reproduced are first set up in clean-cut metal type, which is then thoroughly oiled. A rim or guard about ½ in. high should then be placed around the form and with a camel's-hair brush a thin cream of plaster-of-Paris is laid over it, to exclude all air bubbles. A thicker paste of plaster is then poured over the form, filling in the guard or the rim up to its edge, and it is then set aside to harden. Alum water is often used to mix the plaster, as this makes a harder mould, but it takes somewhat longer to set. When the mould has thoroughly stiffened, it is removed from the type and placed in a dry, hot place to become well hardened. The mould is now fitted in a frame of suitable size, and a strip of sheet vulcanised rubber of the right size and about ⅛ in. in thickness is adjusted upon it, and the whole is put into a screw-clamp and heated slowly until the rubber becomes soft enough to be forced into the letter spaces of the mould by tightening the screw. The rubber should be allowed to remain in the press at least 24 hours, and until it becomes quite cold. The sheet rubber used for this purpose is usually but slightly vulcanised, having had about 3 per cent. of sulphur kneaded into it with rollers while subjected to a very high temperature. After the impression has been made, therefore, it is necessary to add a greater proportion of sulphur, to insure the required hardness in the type. This is done by immersing the rubber, which has been separated from the mould, in a mixture of 30 parts of bisulphide of carbon and 1 part of chloride of sulphur. This is exposed to a temperature of from 70° to 80° F. until all the bisulphide of carbon has volatilised, and is then immersed in a boiling alkaline solution—made by dissolving 9 oz. of caustic potash in 1 gal. of water—for a few minutes, and after a subsequent washing in clear, tepid water, is made quite ready for use.

Rubber Stamp Ink.—(1) The usual rubber stamp inks are prepared with water, soluble aniline colours and glycerine. A good formula is given by Dieterich. Aniline blue, soluble in water, 1 B, 3 parts, distilled water 10 parts, pyroligneous acid 10 parts, alcohol 10 parts, glycerine 70 parts. Mix intimately by trituration in a mortar. (The blue should be well rubbed down with the water and the glycerine gradually added. When a solution is effected, the other ingredients are by degrees added.) Other colours are produced by substituting for the blue any one of the following: Methyl violet 3 B, 3 parts; diamond fuchsin I, 2 parts; methyl green, yellowish, 4 parts; Vesuvin B (brown), 5 parts; Nigrosin W (blue-black), 4 parts. If a bright-red ink is required, 3 parts of eosin B B N are used, but the pyroligneous acid must be omitted, as this would destroy the eosin. Other aniline colours, when used for stamping ink, require to be acidulated.

(2) Dissolve 1 oz. of aniline dye (any colour) in 8 oz. of water and 2 oz. methylated spirit. (*See also* INKS).

* * *

RUSTING AND CORROSION OF METALS.

(*See also* BRONZING, ENAMELLING, *and* PRESERVATION AND STORING.)

SOME substances are applicable to the preservation of most metallic surfaces, and may therefore be mentioned before dealing with those which can be applied only with discrimination. Such may be said to consist chiefly of solid hydrocarbons in combination with liquid hydrocarbons, etheric or fatty oils. Amongst the solid hydrocarbons, preferably india-rubber, paraffin, and ozokerit are used; whilst among the liquid hydrocarbons and oils, rectified petroleum, ligroine, and turpentine-oil are preferably applied for the manufacture of the above composition. A valuable combination is produced by melting 1 part of paraffin under moderate heat (about 150° F.) in a closed vessel, and by then adding and mixing 2–4 parts of rectified petroleum, ligroine, or turpentine-oil with the melted paraffin. According to the greater or lesser quantity of liquid which is added, the consistency of the composition varies. It can be applied to the surface of the metals by means of a stiff brush.

Copper.—The corrosion of copper by oxidation on exposure to the air takes place very slowly, the metal becoming soon coated with a skin of carbonate commonly called "verdigris," though that name is correctly applied to a basic acetate of copper. This familiar film on the surface of exposed copper constitutes a protection against further oxidation. The action of salt water on copper which is also accessible to the air is rapid, but may be in some degree modified by alloying a small proportion of phosphorus with the metal. Dr. Percy has made the remark that for more than a century European metallurgists have been familiar with small thin bars of cast copper, of Japanese manufacture, which present a beautiful rose-coloured tint, due to an extremely thin and pertinaciously adherent film of red oxide of copper, or cuprous oxide. This tint is not in the least degree affected by free exposure of the bars to the atmosphere. He has had such bars in his possession for more than 30 years, and although they have been freely exposed to the atmosphere during the whole of that period, yet they have not undergone the least change in appearance. Every one knows that when a piece of ordinary copper is exposed to the atmosphere, it speedily acquires a dark-coloured tarnish. Hence the conclusion that there is some peculiarity on the surface of the Japanese copper, which protects the underlying metal from atmospheric action, and that peculiarity, it may be demonstrated, is the presence of a film of cuprous oxide, in a particular physical state, which acts like varnish. The bars of Japanese copper are actually cast under water, the metal and the water, previously heated to a certain degree, being poured at a high temperature. When copper is so cast, under suitable conditions of temperature, it acquires a coating of cuprous oxide, which acts in the manner described. The temperature is such that the so-called spheroidal action of water comes into play, and the metal flows tranquilly under the water. The superficial oxidation is probably due to the action of a film of steam, which there is reason to believe surrounds the copper under these conditions; and when copper is heated to a high temperature in steam, the latter, as shown by Regnault's experiments, is decomposed, with the evolution of hydrogen, and the formation of cuprous oxide.

Galvanised Iron.— Messrs. Samuel Courtney state that the best coating for galvanised iron is a good quality of bitumen solution, free from all acids.

Iron and Steel.—The different varieties of iron and steel will not oxidise (rust) in dry air, or when wholly immersed in fresh water free from air, but they all do so when exposed to the action of water or moisture and air alternately. Very thin iron oxidises more rapidly than thick iron, owing to the scales of rust on the former being thrown off as soon as formed in consequence of the expansion and contraction from alternations of temperature. Iron plates are more durable when united in masses than when isolated. The oxidation of iron is to a great extent arrested by vibration. The comparative liability to oxidation of iron and steel in moist air, according to Mallet, is—

Cast iron	100
Wrought iron . . .	129
Steel	133

Cast Iron does not rust rapidly in air. When immersed in salt water, however, it is gradually softened, made porous, and converted into a sort of graphite. Mallet found that the rate of corrosion decreased with the thickness of the casting, being during a century $\frac{1}{10}$–$\frac{1}{40}$ in. in depth for castings 1 in. thick. Stevenson found the decay to be more rapid than this.

Wrought Iron oxidises in moist air more rapidly than cast iron. The evidence as to its rate of corrosion in salt water is rather contradictory. Rennie found that it corroded less quickly than cast iron, but Mallet's experiments showed that it corroded more quickly.

Steel rusts very rapidly in moist air, more quickly but more uniformly than wrought iron, and far more quickly than cast iron. Low shear steel corrodes more quickly than hard cast steel. Recent experiments show that steel immersed in salt water is at first corroded more quickly than wrought iron, but that its subsequent corrosion is slower, and the total corrosion after a long period of immersion is less than that of wrought iron.

Cast Iron Pipes.—In the course of a paper read by McElroy before the Western Society of Engineers, on the causes of corrosion in cast-iron pipes, the author observed that a prominent cause of corrosion is the class of materials used, and also the method of the manufacture of pipes in ordinary foundries. In the first place, a cheap and easily melted pig is selected—specifications and the inspection of quality and mixture not being strict—and the castings (for convenience of handling) are generally made in greensand moulds laid at a slope of about 10° from the horizontal. Impure metal is therefore run in a way that aggravates its defects. The core bars are coated with straw ropes, which may be more or less soft and loose, coated with loam more or less soft and wet, and sprinkled with sand.

If not very carefully wedged, these bars will rise; and they are seldom stiff enough to resist the upward pressure of the molten metal. The usual spring at the centre for the core of an 8-in. pipe is $\frac{1}{16}$–$\frac{1}{8}$ in.; or as much as $\frac{3}{16}$ in. with a 6-in. pipe. The metal, poured in from the upper end, first fills the lower section of the mould; and as it rises round the core to fill the upper section, its weight springs the bar upward to the extent indicated, making the casting thicker at the lower, and thinner at the upper side. The denser, hotter, and purer metal fills the lower portion; the impurities naturally floating upward to settle in the thinner metal as it cools. Here gather portions of the sand coating of the mould; while the bubbles of the metal, caused by the development of gas from the vegetable matter of the loam, and from its dampness, tend to perpetuate themselves in blisters and air cells.

The usual defects in these cheap castings are, therefore, inequality in thickness, air cells and blisters, sand holes, cold chutes from chilled metal, and mixtures of sand and iron. Such pipes are also frequently out of line, from the effect of unequal contraction. Pipes of this description are peculiarly liable to corrosion; containing as they do mixtures of metal of different densities, together with much graphite. The duration of such pipes in the ground is largely affected by the amount of disturbance they receive. If well laid at a good depth, and thoroughly backed, they may continue serviceable for many years; but their defects are likely to become suddenly prominent upon comparatively slight external interference. In favourable circumstances they may last more than thirty years; but the majority, if tested after less use, will show flaws that would have ensured their rejection if detected when new.

Gruner has lately published the results of a year's researches into the comparative oxidisability of cast iron, steel, and soft iron, under the influences of moist air, sea water, and acidulated water. Having done justice to the earlier labours of Mallet, Phillips and Parker, he explains the arrangements made to secure a perfectly fair trial. The following results were obtained. The experiments with moist air are still proceeding; but, so far, it was found that in 20 days the steel plates lost 3–4 grm. for every 2 sq. decimeters of surface. Chrome steel rusted more, and tungstated steel less, than the ordinary carburetted steel. Cast iron lost only about half as much as the steel, and spiegeleisen less than grey iron. Sea water dissolves iron rapidly, and acts upon it more powerfully than on steel, most powerfully of all upon spiegeleisen. In 9 days the steel plates with 2 sq. decimeters of surface lost 1–2 grm. while Bessemer metal lost 3·5 grm., phosphorised iron 5 grm., and spiegeleisen 7 grm. Tempered steel was less affected than the same steel twice annealed, soft steel less than chrome steel, and tungstated steel less than the ordinary steel with the same proportion of carbon. It is evident from these experiments that manganese sheets ought not to be used on the hull of a vessel. Acidulated water dissolves cast iron much more rapidly than steel, but not speigeleisen. ('La Metallurgie.')

In the rusting of iron there is

formed, together with an evolution of hydrogen (which combines with nitrogen, forming a small quantity of ammonia), ferrous carbonate. This changes very quickly into ferric hydrate, mixed with ferrous oxide, and enclosing some unaltered ferrous carbonate. The presence in rust of ferrous oxide, carbonic acid, and ammonia is thus explicable. Rust formed under water is, in consequence of the smaller amount of acid present, usually richer in protoxide of iron, and therefore a little magnetic, and of a deeper tint than that formed in air. It is accordingly assumed that the carbonic acid present in the atmosphere and in water acts, in the production of rust, similarly to those acids in which iron dissolves, the only difference being that, in the rusting of iron, the ferrous salt first formed changes, before it is dissolved, into basic ferric salt or ferric hydrate, which change is a natural result of the solution of iron in an insufficient quantity of the acid or water present, or both. The denser the iron, the smoother and more even its surface, the less is the contact between it and the attacking substances, and, under otherwise similar conditions, so much the better, of course, will it withstand rusting. If the latter has begun, it promotes its own further formation, as rust, like other porous bodies, absorbs gases and therefore takes up moisture and acids from the air. Besides, where rusting has already begun, the change from the first-formed ferrous compound to ferric hydrate is attended by a setting free of the active acid, which is then in a condition to act powerfully in the formation of fresh rust. Rust already formed must therefore be quickly removed, in order that a new layer shall not be produced. Rusting, being promoted by acids existing in the air, is also accelerated by those present in water, and for this reason iron is destroyed more quickly in marshes and bogs than in lakes or considerable currents of water, which are generally comparatively free from acids. The tendency of iron to rust is also increased by some salts dissolved in water. Thus it is explained why pieces of cast iron can, by long immersion in sea water, be changed to loose masses, retaining the same outward form, but consisting essentially of carbon. Iron which has been metamorphosed in this manner contains more carbon in proportion to the completeness with which the iron itself has been dissolved. The mass, when taken out of the water, possesses a low specific gravity, and such great porosity that a condensation of air and simultaneous rise of temperature take place, sometimes sufficient to cause the spontaneous ignition of the whole. If a substance negative to iron, such as scale, tin, etc., partially covers its surface, the portions coated are of course protected, but the uncovered portions are only so much the more liable to rust: therefore, before coating pieces of iron with oil-paint one should free them from all scale by the action of dilute acid. If, as appears to be the case, contact with impurities renders iron positively electrical, their existence in its interior must also promote rusting. Thus, forged iron appears to rust first along the bands of impurity occurring in it. A partial coating of a metal positive to iron, such as zinc, not only protects the covered portions of the iron, but also hinders the rusting of the unprotected parts, the more completely, indeed, the smaller they are. A coating of fat also protects iron, for some time; but when the fat, by absorption of oxygen from the air, has become rancid and in part changed into fatty acids, the tendency of the iron to rust is increased. From the part which galvanic influences take in the rusting of iron, it follows that those substances positive to iron, which, when in mere contact with it, prevent it from rusting, *promote* the same if they are alloyed with the iron, because such alloys are in general more positive than iron itself. Thus, manganese alloyed with iron promotes the tendency of the latter to rust. So long, however, as the quantity of manganese is uniform and not too large, its effect in this direction is inconsiderable. If, on the other hand, the quantity is uniformly distributed, the rusting of the portions of iron richer in manganese, and therefore more positively electrical, must be greatly promoted by contact with those parts poorer in manganese; hence the presence of unequally distributed quantities of manganese appears to largely augment the tendency of iron to rust. Association with electro-negative substances, such as carbon and phosphorus, diminishes the tendency of iron to rust, if the quantities of the electro-negative substances be evenly distributed through its whole mass. But iron poorer in metalloids in contact with iron richer in these bodies becomes more positively electrical, and thus the rusting of the poorer portions proceeds more rapidly. Sulphur is an exception among the metalloids, inasmuch as it promotes rusting. Forged iron rusts more easily. With an increase in the amounts of carbon, silicon, and phosphorus present in iron, the tendency to rust diminishes, so that cast iron is the more capable of resistance to rusting, accordingly as it contains more combined carbon, silicon and phosphorus, and becomes denser. Grey cast iron is, as is well known, poorer in combined carbon and less dense than white. Both characters induce a greater tendency to rust. Perhaps the mechanically-contained graphite also contributes to this, as galvanic action may arise from its contact with the iron. In spite of its lower density and the contained graphite, grey cast iron withstands rusting better than steel, although the amount of combined carbon in the latter is probably at least as large as in the former. This is probably accounted for by the greater freedom of steel from silicon and phosphorus. The circumstance that grey iron smelted with coke is less soluble than that obtained from charcoal may be similarly explained, viz., by its greater proportion of silicon, and probably also, phosphorus. Spiegeleisen withstands rusting better than granular white cast iron by reason of its greater density and larger amount of carbon. Elaborate experiments in connection with this subject were made by Parker, whose results are for the most part in accordance with the foregoing statements. (Akerman.)

Protection.—(1) *Galvanising.*—This consists in covering the iron with a thin coating of zinc. The iron is cleaned by being steeped for some 8 hours in water containing about 1 per cent. of sulphuric acid, then scoured with sand, washed, and placed in clean water. After this the iron is heated, immersed in chloride of zinc to act as a flux, and then plunged into molten zinc, the surface of which is protected by a layer of sal-ammoniac. The process differs slightly according to the size and shape of the article. It is a simple one, and may be applied to small articles in any workshop. Kirkaldy found that galvanising does not injure iron in any way. The zinc protects the iron from oxidation so long as the coating is entire; but if the sheet-iron be bad, or cracked, or if the zinc coating be so damaged that the iron is exposed, a certain action is set up in moist air which ends in the destruction of the sheet.

The sheets are generally galvanised before they are corrugated; but as in process of corrugation the sheets, especially the thicker ones, sometimes crack slightly on the surface (unless the iron is of the very highest quality), it is an advantage, with all sheets thicker than 20-gauge, to galvanise after corrugation, so as to fill up with zinc any cracks that may have occurred. As, however, a larger quantity of zinc adheres to the corrugated than to the flat sheets, they have, when so coated, a distinctly higher value.—'Matheson.'

(2) "*Sherardising,*" *or Dry Galvanising.*—This process is named after its inventor, and consists of giving

metals a durable coating of zinc without heating the zinc to melting-point. The first process—that of cleaning—can be done in the same way as for galvanising, viz., dipping in dilute acid or sand-blasting. The articles are then put into a suitable receptacle—a kind of retort—and surrounded with zinc dust, then subjected to the heat of fire or gas until they reach 500° to 600° F. The heat is kept up for a few hours, according to the size of the article and the thickness of coat required, after which the whole is allowed to cool before the receptacle is opened. The heat just stated is some 200° below the fusing temperature of zinc, and the broad result is not only a reliable coating to the article being treated, but a marked economy in fuel, in zinc, and in the process generally. It may also be noted that the lower temperature has less ill effect on articles which are susceptible to heat—steel for instance. The process may be employed upon most metals and when applied to copper it becomes surface or case-hardened to a remarkable extent.

The zinc used is a powder obtained in distilling zinc from its ores. It must not be confounded with zinc oxide. It is readily obtainable, being the zinc dust of commerce, costing about 20*l.* per ton. Strange to say, this dust is not readily fused or reduced to its metallic form, therefore any overheating is very unlikely to melt the dust in the retort or process drum. The retort should be air-tight if possible, and it is desirable to exhaust the air from within it. If this cannot be done about 3 per cent. of fine powdered carbon should be put in with the zinc to prevent zinc-oxide being formed too freely. The only fault of the presence of zinc oxide beyond a certain amount is that the deposit on the articles assumes a dull hue instead of being bright. The deposit itself may be as good, but of somewhat poor appearance. A rather extraordinary detail of the process is that grease on the articles is not objectionable; if anything, its presence affords better results. Consequently machine-made bolts, screws, etc., can be put into the process drums without cleaning. It need scarcely be pointed out that the process does not require the retorts to be kept hot continuously, as a zinc bath for galvanising has, and if the demand is not great small retorts, heated by Bunsen burners, can be put to use and complete an order in a few hours, starting cold. A small plant to take about 2 cwt. of moderate-sized articles would consist of a horizontal drum, made to revolve, its revolution not being continuous, but occasional, just sufficient to keep all parts thoroughly hot. One of the trunnions should be hollow to take a pyrometer. The drum would be encased with cast iron lined with fire-brick (to prevent loss of heat) or by brickwork only. The heat would be provided by a row of Bunsen burners beneath. Producer gas is quite suitable. Larger retorts could not be made to revolve, but can be arranged to run (on trucks) into a tunnel-shaped, brick-built, furnace chamber of such a form that, whether fire or gas heat be applied, the heat entirely envelopes the retort. Retorts must of necessity be of whatever shape the work requires, but the cylindrical is best when possible.

(3) A substitute for galvanising has been invented by Neujean and Delaite, of Liege. It is specially intended for objects of large dimensions, which cannot easily be moved, and therefore cannot well be dipped into a bath of melted zinc. The zinc, when finely pounded, is simply mixed with oil and siccative. In this way a varnish is obtained, which is applied with a brush in the usual manner. A single layer is sufficient, but two are preferable. The coated objects can be left as they are, or bronzed and painted as required.

(4) *Painting.*—(*a*) This is an effectual method of preserving iron from oxidation, if the paint is good and properly applied, and the iron in a proper condition to receive it. In order that the protection by painting

may continue, the surface should be carefully examined from time to time, so that all rust may be removed. The paint may be renewed directly it is necessary.

(5) Cast iron should be painted soon after it leaves the mould, before it has time to rust. The object of this is to preserve intact the hard skin which is formed upon the surface of the metal by the fusing of the sand in which it is cast. After this a second coat should be applied, and this should be renewed from time to time as required. In any case, all rust upon the surface of castings should be carefully removed before the paint is applied. Small castings are often japanned. Before painting wrought iron care must be taken to remove the hard skin of oxide formed upon the surface of the iron during the process of rolling, and which, by the formation of an almost imperceptible rust, becomes partly loose and detached from the iron itself. An attempt to prevent this rusting is sometimes made by dipping the iron, while still hot, in oil. This plan, however, is expensive, and not very successful. The scale is sometimes got rid of by "pickling," the iron being first dipped in dilute acid to remove the scale, and then washed in pure water. If the trouble and expense were not a bar to its general adoption, this is the proper process for preparing wrought iron for paint, and it is exacted occasionally in very strict specifications. But somewhat the same result may be obtained by allowing the iron work to rust, and then scraping off the scale preparatory to painting. If some rust remains upon the iron, the paint should not be applied lightly to it, but by means of a hard brush should be mixed with the rust. Ordinary lead paints, especially red lead, are often used for protecting ironwork, but they are often objected to on the ground that galvanic action is set up between the lead and the iron. Matheson recommends oxide of iron paints for ironwork generally, and bituminous paints for the inside of pipes or for ironwork fixed under water. The ironwork for roofs, bridges, and similar structures generally receives one coat of paint before it leaves the shops, and two or three more after it is fixed.

(6) *Dr. Angus Smith's process* is an admirable means for preventing corrosion in cast-iron pipes. The pipes, having been thoroughly cleaned from mould, sand, and rust, are heated to about 700° F. They are then dipped vertically into a mixture consisting of coal-tar, pitch, about 5–6 per cent. of linseed oil, and sometimes a little resin, heated to about 300°F. After remaining in the mixture several minutes, long enough to acquire the temperature of 300° F., the pipes are gradually withdrawn and allowed to cool in a vertical position. Perfect cohesion should take place between the coating and the pipe, and the former should be free from blisters of any kind. In practice, the heating of the pipes before immersion is found to be expensive, and is frequently omitted, but this practice is fatal to good results. The coating is not then so lasting, and, what is worse, it gives a taint of tar to water passing through. There is no taint if the coating is properly done. The cheapest plan for an effectual coating is to dip as soon as possible (while the metal is still hot enough) after the pipes come from the mould. Most pipe founders are prepared to do this.

(7) *Dr. Percy* recommends resin melted with a little Gallipoli oil and spirit of turpentine, of such proportions as will make it adhere firmly without chipping off, yet admit of being easily detached by gentle scraping.

(8) *Ventura Serra*, after many years of experiment and observation, having noticed that knives used in cutting plants belonging to the family of Euphorbiaceæ did not rust, is led to recommend for this purpose an alcoholic solution of gum (resin of) euphorbium. This when applied to steel, iron, or copper forms a thin, uniform, and very adherent layer, which effectually protects the metal. Experiments with

copper immersed in sea-water—a ship's sheathing—were followed by gratifying results.

(9) *J. Machabee* invented the following composition:—Virgin wax, 100 parts; Gallipoli, 125; Norwegian pitch, 200; grease, 100; bitumen of Judea, 100; gutta-percha, 235; red-lead, 120; white-lead, 200. These ingredients are mixed together in a boiler in the order above, the gutta-percha being cut up in small pieces, or rasped. The mixture is stirred at each addition, and poured into moulds. For iron, it is melted and laid on with a brush.

(10) Girders, angle-irons, and similar large masses of iron, are often placed in exposed situations, where damp air, steam, and acid vapours have access. If the iron be put up in the rough, it very speedily rusts, and under favouring conditions the corrosion soon reaches a dangerous point. Contractors generally agree to supply such irons painted in three coats of minium, which, if honestly done, to a certain extent protects the metal; but a novel mode of treating girders is to heat them until, if touched with oil or fat, they cause it to frizzle, and then plunge them into a vat of mixed oil and grease. This mode of treating cast iron is said to be superior to any "painting," as the oleaginous matter actually penetrates the pores, and prevents oxidation for a very long time, while it does not prevent painting, if desirable, afterwards.

(11) The results of some experiments on the preservation of sheet-iron used in railroad bridges were published by the directory of the Government railroads of the Netherlands. From 32 sheets half were cleaned by immersion for 24 hours in diluted hydrochloric acid; they were then neutralised with milk of lime, washed with hot water, and, while warm, dried and washed with oil. The other half were only cleaned mechanically by scratching and brushing. Four of each kind were then equally painted with red-lead, with two kinds of a red paint of oxide of iron, and with coal-tar. The plates were then exposed to the weather, and examined after three years. The result was—(*a*) That the red-lead had kept perfectly on both kinds of plates, so that it was impossible to say if the chemical cleaning was of any use. (*b*) That one kind of iron oxide red paint had better results on the chemically-treated plate than on the other—in fact, a result equal to that of the plate painted with red-lead; while the other kind of iron oxide red gave not very good results on the plates when only scratched and brushed. (*c*) That the coal-tar was considerably worse than the paint and had even entirely disappeared from those iron sheets which had not been treated chemically, but only cleaned by brushing. ('Eng. Mech.')

(12) *Cast-iron Pipes.*—The water from mines frequently contains enough acid to attack cast-iron pipes, destroying them in a short time. Oil colours and varnishes offer but a limited resistance, and the process of enamelling employed in Oberschlesia, says Engelhardt of Ibbenburen, although permanent and effective, is expensive. Cement is cheaper, and is unacted upon by these waters, and the only question to be settled was whether it would adhere to the smooth iron with sufficient firmness. Two similar pieces of rolled iron were taken, and one of them painted over five times with a very thin cement, so that the coating was $\frac{1}{5}$ in. thick. Both pieces were suspended near together in that part of the shaft where the water had attacked the signal cable most violently, and were left there four months. On taking them out, the unprotected iron was found to be reduced to $\frac{1}{3}$ its original thickness; the other, in which a hole had been bored to suspend it, had suffered the same corrosion at the exposed portion; the cement covering was dark brown, but perfectly hard and unattacked by the acid. The cement was broken off, and the surface of the iron exhibited the dark-blue colour and lustre that it had on leaving the rolls. As this coating adhered so well to the smooth rolled iron, to which it

cannot cling so tightly as to the rougher surface of cast iron, the experiment was continued on a larger scale. A 26-in. discharge pipe in the Oeyhausen shaft was protected on the inside with cement. The coating remained unchanged for 2 years, while the pump was in constant operation. At the beginning of last winter the pump was stopped, and the pipe being no longer under water the cement was so much injured by the frost that it scaled off. Several other experiments were made with similar results. The pipes should be new, or, if old, well cleaned from rust before applying the cement, which is mixed as thin as is possible without injury to its tenacity. The pipe is moistened before the cement is applied, a thin coating of cement is put on and allowed to dry; when hard it is moistened, and a second coating is applied; and so on four or five times. The operation cannot be conducted so well in very hot weather, as the cement dries too quickly; nor must the pipes be exposed to frost during the operation or afterward. This unfortunate sensitiveness to cold may perhaps yet be overcome by interposing some semi-elastic material between the iron and cement. ('Iron.')

The cement being a compound of lime would probably owe its efficacy to this fact. See next paragraph.

(13) *Lime as a Preventative of Rust.*—Of late years it has been recognised that lime—ordinary builders' lime—when in contact with iron, opposes the rusting process. Small bright goods, as surgical needles, buckles, scissors, etc., if kept in paper with lime dust just dusted on them, escape rusting under usual conditions. To see to what extent lime had this property the writer made the following experiment. Several 4-in. test tubes were filled with water, some with soft rain water, some with tap water which was fairly hard. In each tube two clean sewing-needles were put, and in a certain number a small piece of lime (about the size of a pea) was added. The lime varied, some being "quick," some slaked, some plaster, and in one case a piece of mortar. Some of the tubes were corked, some not. These tubes stood in an outhouse for about two months, then outdoors in winter weather, unprotected, for about three months. A few were frozen and broken, but in the remaining cases there was extraordinary proof of the protective effect of the lime. In every case the needles that had lime with them were absolutely like new. When restored to the work-box they were used as new ones. In all other cases the needles were a mass of spikelets of rust, rather worse with the rain water than the tap water. Those who have to do with water supplies know that in hard-water districts—the water having a percentage of chalk or lime in solution—plain iron pipes may be freely used, without any trouble occurring by their rusting, whereas in soft-water districts, the use of such pipes makes the water unfit for use by its red colour due to rust. The application of lime wash has been found beneficial in the case of rusty tanks and cisterns.

(14) *Sterling's process* consists in the impregnation and saturation of the structure of the metal with a non-oxidising or non-oxidisable substance, by forcing it into the intercellular spaces of the metal by pressure while the iron is in an expanded condition, induced by heating. He gives one method by which his invention may be applied, and which he recommends as being eminently practical and useful. A vessel of any suitable material, of sufficient strength, is made in the form and size best adapted to those of the iron article to be treated, with the lid so constructed that the vessel may be closed hermetically; at the bottom, pipes are arranged for conveying steam and water alternately, for the purpose of heating and cooling the interior. Connected with this vessel is a force-pump, for producing the necessary pressure, and appliances for obtaining a vacuum. The iron to be treated is heated to the desired temperature, placed in the above vessel, the top is

closed hermetically, and dry or superheated steam is turned into the pipes at the bottom to keep the metal at the required temperature; also, at the same time, an atmospheric vacuum is produced by an ordinary air-pump connected with the chamber; the proper quantity, sufficient to fill the vessel, of pure paraffin or paraffin in solution with one of the pure mineral oils, having been also previously heated to the required temperature, is now let into this chamber and forced under pressure into the intercellular spaces of the iron, those having so enlarged by the expansion of the metal from the heat and removal of the atmospheric pressure as to readily admit the hydrocarbon preservative. When the iron has remained under this liquid pressure a sufficient time it is gradually cooled by turning cold water instead of steam into the pipes, the pressure being kept up, however, until the iron is cool. Certain qualities of iron may be treated without the atmospheric vacuum, but as the iron expands very much more, while greater pressure is obtainable by its employment, and the additional cost is not to be considered, he recommends its use as desirable. ('Van Nostrand's Magazine.')

(15) In mixing paints for iron surfaces it is of the first importance that the best materials only should be used. Linseed-oil is the best medium, when free from admixture with turpentine. A volatile oil like turpentine cannot be used with advantage on a non-absorbent surface like that of iron, for the reason that it leaves the paint a dry scale on the outside, which, having no cohesion can be readily crumbled or washed away. Linseed-oil, on the other hand, is peculiarly well adapted for this purpose. It does not evaporate in any perceptible degree, but the large percentage of linolein which it contains combines with the oxygen in the air and forms a solid translucent substance, of resinous appearance, which possesses much toughness and elasticity, and will not crack or blister by reason of the expansion or contraction of the iron with variations of temperature. It is, however, remarkably adhesive, impervious to water, and is very difficult of solution in essential oils, spirits, or naphtha, and even in bisulphide of carbon. Another important advantage of linolein is that it expands in drying, which peculiarity adapts it to iron surfaces; since cracks, however minute, resulting from shrinkages, expose enough of the metal to afford a chance of corrosion, which will spread in all directions, undermining the paint and causing it to scale off, besides discolouring it. With all its advantages, however, the best linseed-oil paint is but poorly adapted to long service as a protection to iron surfaces exposed to extreme variations of temperature and to all kinds of weather. Even the continuous film of linolein, notwithstanding its compactness and the additional substance afforded by the body of the paint, gradually loses its toughness, curls up, and peels off. If chipped by accident before it has lost its hold on the iron, we find, if we carefully examine the exposed spot, that a thin film of oxide has formed under it. This fact accounts for its diminished adhesion. Iron, in uniting with oxygen to form a rust, increases its bulk in proportion to the amount of oxygen it has taken up, and necessarily occupies greater space. In a word, it swells, and in so doing pushes off from it the paint film, which sooner or later drops away from it. This undermining action of rust is the chief difficulty to be contended with in effectually preserving iron surfaces by means of paints or varnishes. It is not improbable that the linolein, itself an oxide, may impart oxygen to the iron, and thus promote rusting. This idea has been suggested by Prof. Williams in a recent treatise on the subject; and, whilst purely speculative, it may account for the oxidation of iron surfaces when to all appearance effectually protected by a coat of paint thick enough and continuous enough to exclude both

air and damp. In selecting a paint for iron, mechanical adhesion is a consideration of the first importance. In this respect paints differ widely; but it must be remembered that in painting or varnishing a metallic surface, mechanical adhesion is all we have to depend upon. With absorbent surfaces it is different. Prof. Williams gives it as his opinion, based on observation and experiment, that pitchy or bituminous films are especially effective as regards their adhesion to iron; for example, solutions of asphalte, or pitch, or petroleum, or turpentine. These are also very effective as regards continuity, owing to the fact that in drying they form plastic films, which yield with the contraction and expansion of the iron, and show no tendency to crack. If the surface is rusty, they penetrate the oxide scale and envelope the particles very effectually, making them a portion of the paint. The solubility of such a film may be counteracted by mixing it with linseed-oil. The experiment may easily be tried by mixing about two parts Brunswick black with one of red- or white-lead or litharge. Red-lead is the best for many reasons, if finely-ground and thoroughly mixed with linseed-oil. Any one of the several kinds of bitumen may be used; either natural mineral asphalte, pine pitch, or artificial asphalte, such as gas-tar or the residuum of petroleum distillation in cases where the crude oil has been distilled before being treated with acid. This gives a very hard bright pitch, which is soluble in "once run" paraffin spirit, and makes the base of an excellent cheap durable paint for ironwork in exposed positions. During the past few years have appeared many accounts of the preservative influence of paraffin when applied to iron surfaces, and recommending it in all classes of ironwork which can be treated hot. The most effective mode of applying it is to heat the iron *in vacuo*, in order to expand it and open its pores, when paraffin raised to the proper temperature is poured into it. By this means the iron is penetrated to a sufficient depth to afford a very effectual protection against oxidation, especially when a suitable paint is subsequently applied. Any non-oxidisable substance would probably answer, but paraffin is as cheap as any, and quite as good, if not better; the exception as to quality being made in favour of some vitreous enamel, which, while costing more, would certainly be more permanent in its results. Brushed upon the outside merely, it is doubtful whether paraffin would have much effect upon the iron, while it certainly would tend to lessen, if not destroy, the mechanical adhesion of a surface paint. There is no reason, however, why bridge-work, iron fronts, etc., should not be treated with paraffin before they leave the shops where they were made, which would greatly simplify the problem of their easy and economical preservation from oxidation. In the absence of such treatment, a careful coating with the paint above described will probably prove the most effectual means of protecting iron surfaces. ('Amer. Painters' Mag.')

(16) *To Coat Stoves, Tools, etc.*—Metallic tools and other articles, particularly those of iron and steel which are used in laboratories and other workshops where acid vapours are of frequent occurrence, can be protected with a lustrous black coat which resists acids, and is but little affected even by a low red heat, as follows: Have a sheet-iron box constructed large enough to hold all the articles to be coated, and provided with a false bottom of wire netting about 1½ in. above the actual bottom. Underneath this wire netting is placed a layer of crushed blacksmith's coal about ¾ in. deep; then place the articles, which must be entirely free from rust, clean and polished, upon the wire net. The box is then covered with a well-fitting lid and set on a strong fire, which causes the coal to give off tarry constituents, the heat being continued until the bottom of the box is at a red heat. When all evolution of gas has

ceased the box is allowed to become cold, and the articles are taken out, and will be found covered with a beautiful glossy coat.

(17) *Ward's Inoxidising Process.*—This process is based upon the simultaneous employment of silicates and heating. The cast or wrought iron articles are coated by means of a brush or by immersion with a silicate. This coating dries quickly, and when the articles are exposed to a suitable heat liquefies, penetrates the pores of the metal, and after cooling forms a dense uniform coating of a dead-black colour, which does not change by the action of the atmosphere nor crack off from the article. By adding to the silicate pigments used for colouring glass, decorated surfaces of great beauty may be obtained, which are far superior to those produced in the ordinary manner by the application of paint.

(18) *Inoxidising Process for Cast Iron.*—The cast iron articles, entire gas-chandeliers, water pipes, ornamental pieces, railings, kitchen-pots, etc., are placed upon an iron carriage and first exposed in a reverberatory furnace of special construction at a temperature of from 1112° to 1292° F. for 15 minutes to the oxidising, and then for 20 minutes to the reducing action of gas generators. After removal from the furnace and cooling, the inoxidised articles acquire a uniform slate colour; they may, however, be enamelled and decorated in any manner desired. In applying the enamels pickling with acid is not necessary, and consequently the enamel adheres very firmly. Various articles exposed in the open air for two years to all kinds of atmospheric influences showed no trace of deterioration. Numerous experiments have demonstrated that the tensile strength of the iron is but little decreased by inoxidation, in fact, no more than by annealing. As regards the durability of the surface layer with a high load, it has been determined that from wrought iron bars it cracked off in the form of small lamina with an average tension of 4000 lb., but from cast iron it did not crack off even with a breaking load.

(19) *Bower-Barff Process.*—Briefly, this process, as now worked, is as follows: The iron goods, whether rusty or not, are, without preliminary treatment of any kind, placed in a suitable chamber sufficiently capacious to hold about one ton weight of contents, and this chamber is heated by the combustion therein of carbonic oxide gas, produced near at hand by several gas furnaces, an excess of air over that requisite for combustion being admitted also into the chamber, after having been heated in its passage through coils of pipes placed immediately underneath the operating chamber. A film of magnetic oxide forms upon the immediate surface of the iron articles, and this appears to be surmounted with one of ferric oxide (Fe_2O_3) and it is by the subsequent reduction of this substance by means of carbonic oxide that the coating of magnetic oxide is increased to the requisite extent. In brief, the excess of air present in one stage of the process seems to form ferric oxide, and when the proportion of air present is reduced (as it may be at will) so that carbonic oxide is present, then the ferric oxide becomes reduced to the lower state of oxidation, its oxygen contributing to the production of carbonic anhydride. The time required varies from 3 to 12 hours, and the magnetic oxide as thus formed exhibits a very pleasing French-grey or leaden tint. Should the colour, however, be unsuitable to the intended use of the iron articles, the more costly metals may be deposited upon them. (Kingzett.)

Prof. Barff has at various times published further details of the results of the process. As to the action on the strength of the iron, bars treated have been tested for breaking and tensile strain, and the result is that the strength of the iron is not affected. The coating gives great hardness to the surface of iron, when the coating is sufficiently thick (even less than $\frac{1}{16}$ in.). An ordinary flat rasp will not remove it without great labour, and it resists emery powder, will for a long time resist a rasp, and remove pieces of steel from it. Substances which adhere to iron, zinc, and enamel will not adhere to it. Saucepans in which sticky substances are cooked can be cleaned with the greatest ease, after they have been oxidised, a simple wipe removing all dirt. A urinal in constant use for months had no deposits on it. Water was evaporated in an oxidised pan for six weeks—common tap water; the water never boiled, but was slowly evaporated; the deposit found was removed with a duster: it did not stick to the iron. This is a matter of great importance to boilers, and for pipes through which water is to be conveyed. Articles coated can be submitted to a high temperature, even a red heat, without the coating being injured or disturbed. At present iron wire cannot be treated successfully—the wire can be treated and will not rust, but it cannot be bent to a sharp curve without the coating coming off. Riveted iron plates can be most successfully treated; the process tightens the rivets and assists the caulking. Weights were treated for the Government, and submitted to tests, and the process is now recommended by the department for the standard weights throughout the country. Prof. Barff has not yet met with any sample of cast iron which could not be properly treated. Wrought iron requires a somewhat different treatment; a lower temperature, about 900° F. (493° C.), suits it best, and steel also. It is not well to expose articles very different in bulk at the same time; all that are put into the muffle should be pretty nearly equal in bulk. For instance, very heavy articles, such as a 56-lb. weight, should not be treated with gutter spouts. Cast and wrought iron should not be treated together. For the chamber at present in use, 2 ft. × 2 ft. 6 in., and 1 ft. 6 in. high, the outlay on fuel for subjecting the articles within the chamber to superheated steam for 10 hours is 5*s*. In a manufactory this cost would be greatly reduced. A West Bromwich firm, working the patent under a royalty, inform him that the cost will not approach that of galvanising iron, and he supposes that it will little exceed that of the periodical three-coat paintings. The increase caused by oxidation can be estimated, and to fit nut and screw for each other, allowance must be made for this in casting. As to the treatment of riveted articles, and the danger that the coating film would be removed, there is some difficulty in this; he supposes boilers will be treated in large chambers when made up. When the rivets are hammered or pressed into the plates, the coating is removed, and of course these spots would be attacked by rust. The remainder of the plates might be protected from abrasion; the practical difficulty is to re-oxidise the rivets *in situ*. To accomplish this he proposes to cover the band of rivets with a porous cap of silicate cotton, and to subsequently re-oxidise that portion. But even if this were not successful, the rusting of the rivets would be of little practical injury, as it would take so many years to rust through a rivet, and the corrosion could not spread laterally, on account of the repellent character of the black oxide. As to the pressure of steam in the boiler, 40 lb. is the extreme; but they are obliged to use considerable force to effect the double object of keeping out atmospheric air and to efficiently oxidise the surfaces treated. The oxidation only proceeds till the pores of the iron are all filled up with black oxide; but with very thin objects, great caution has to be taken, lest they should be oxidised through.

(20) The method of preserving iron by forming an inoxidisable film or coat upon the surface has been tried in France, the process adopted being modifications of those patented by

Barff and Bower. According to Krafft, Bourdon encloses the articles to be preserved in a cylinder closed at both ends by riveted plates, into one of which the steam supply pipe enters, while the other is supplied with three openings. Into one of these a thermometer is fitted; the second is supplied with a stopcock, through which to allow the water condensed to run off. This must be done frequently, as the steam must be as dry as possible. To the third is fitted an escape-valve for the steam. The most favourable conditions for success are the following:—The pressure must amount to 2 or 2½ atmospheres; the temperature must be from 626° to 644°F. (330° to 340°C.), and 5 hours must be allowed for the completion of the operation. A covering of a greenish-black colour is obtained, which adheres firmly and is perfectly stable. The cylinder is placed in a sort of oven, maintaining its shell at about 930°F. (500°C.). The thermometer, plunged in the steam of the interior with its registered part protruding so as to allow observations, showed, however, only 644° F. (340° C.). If the current of steam is stopped, the thermometer will almost instantly rise to 930°F. (500°C.). The coating is a perfect success; care must, however, be taken that no parts of the articles are soldered together by tin solder, as the latter melts at 442°F. (228°C.). Even if the connection remains intact, there will always be a few minute globules of solder detached and stains caused. Copper must be used instead. In further following up his experiments, Bourdon conceived the idea of replacing the steam by hot air. He proceeded as follows:—A coil of pipe communicating at one end with the open air ascends gradually through a reservoir heated to 248°F. (120°C.), whence it enters the cylinder in which the articles to be operated upon are enclosed. This cylinder is identical with that used for steam. The escape-valve leads into a tank containing water, permitting a better regulation of the air current. This must pass very slowly. The interior pressure is but a little above one atmosphere, as the apparatus communicates with the open air. The temperature of the air in the cylinder is 536°F. (280°C.); the time consumed, 5 hours. A layer ⅛ in. in thickness is obtained, capable of resisting the action of emery-paper, and unaffected by dilute sulphuric acid. The layer possesses a fine greenish-black colour. To ensure perfect success the articles must be suspended completely free. After removing them from the apparatus, they are rubbed with a greasy cloth; stains, if any, are removed with emery-paper or iron-dust. It has been found that with an elevation of temperature under pressure of one atmosphere a very thick layer is obtained, which, however, scales off easily. The adherence is, therefore, a question of temperature and not of pressure, as was formerly supposed. Those pieces coated by hot air were for one month exposed to the weather without being attacked in the least. On removal of the exterior black rind, a grey layer is discovered below the same, which to some extent becomes rusty on exposure. The rust, however, does not adhere as on metallic iron, but is easily removed by scraping with a piece of wood. This fact also applies to articles coated by steam. Last June, Bourdon tried the process on 400 rifle barrels at once. Similar trials have since been made, showing the practicability of using it on a large scale. The principal point is to obtain a current of air sufficiently abundant to secure a proper thickness of the layer, but of a circulation slow enough to allow the air to act on the iron. The French Government has already adopted the process at some of its arsenal manufactories.

(21) **G. W. Gesner's process for giving articles of iron and steel a rust-proof coating is shown by the accompanying illustrations, Figs. 19, 20, and 21.** It consists substantially of a bench of two ordinary gas retorts placed side by side in a furnace heated by a grate. Each retort is heated to a

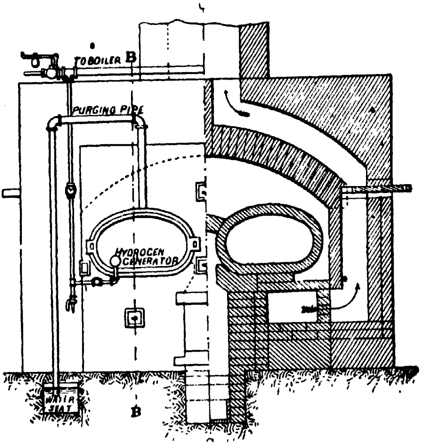

TO BOILER
B
PURGING PIPE
HYDROGEN GENERATOR
WATER SEAL
B

FIG. 19.

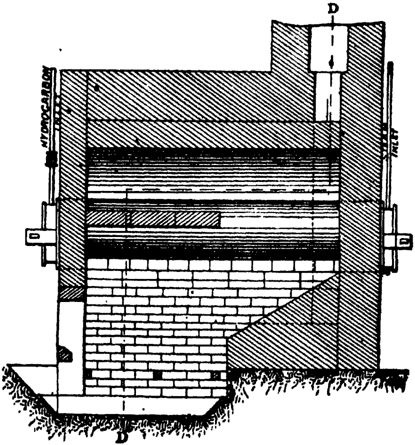

D
HYDROCARBON
INLET
D

FIG. 20.

temperature of 1000-1200°F., as may be determined by the character of the articles to be treated. The latter are introduced by means of a crane and pulley, care being taken that they do not touch one another. After closing and testing the retort, the heating continues for about 20 minutes. Then steam is introduced into what Gesner calls a "hydrogen generator," shown in Figs. 20 and 21. It is a simple pipe, open at the rear end. Gesner claims that in the passage of the steam through this generator hydrogen is generated, which fills the retort. This operation goes on for 35 minutes, at the end of which time ½ pint of naphtha is permitted to flow into the retort for 10 minutes. The flow of hydrocarbon is then stopped, and the steam which has been allowed to enter the generator during the whole operation is continued for 15 minutes longer. The whole time employed in the operation is therefore 1 hour and 20 minutes. The "purging-pipe," which dips into an open vessel of water, as shown in Fig. 19, to the depth of 1½ in., carries off any excess of gases produced in the operation. In cases where articles treated are ornamental, such as art hardware, they are given a bath of cold whale oil or paraffin oil to render them more even in tone. In other articles no oil is used.

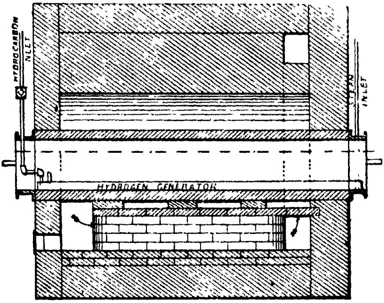


FIG. 21.

To substantiate his claim that hydrogen has a function in the creation of a rust-proof coating, Gesner quotes the following analysis, made by Stillman and Gladding, of New York, of a sample of the surface of cast iron prepared by the process: Carbon, 1·01 per cent.; hydrogen, 0·22 per cent.; sand, 6·70 per cent.; and iron, 66·10 per cent. The chemists add that the iron is present as metallic iron and as oxides of various constitution.

(22) A simple and economical way of tarring sheet iron pipes to keep them from rusting is the following:—The sections as made should be coated with coal tar and then filled with light wood shavings, and the latter set on fire. The effect of this treatment will be to render the iron practically proof against rust for an indefinite period, rendering future painting unnecessary. In proof of this assertion, the writer cites the example of a chimney of sheet iron erected in 1866, and which, through being treated as he describes, is as bright and sound to-day as when erected, though it has never had a brushful of paint applied to it since. It is suggested that by strongly heating the iron after the tar is laid on the

outside, the latter is literally burnt into the metal, closing the pores and rendering it rust-proof in a far more complete manner than if the tar itself was first made hot and applied to cold iron, according to the usual practice. It is important, of course, that the iron should not be made too hot, or kept hot for too long a time, lest the tar should be burnt off. Hence the direction for the use of light shavings instead of any other means of heating. ('Gas Light Journal.')

(23) Crace Calvert some years ago drew attention to the fact that steel after immersion in caustic soda or caustic potash is preserved from liability to rust. This apparently valuable information does not seem to have been acted upon by chronometer makers and others, to whom any method of securing immunity from rust would be of considerable service. Balance springs for chronometers have been occasionally coated with collodion, but the thickness and rapid decay of this film interferes with the timekeeping of the chronometer, and is therefore objectionable. On inquiring of one chronometer maker, we were told that he had treated some springs with caustic soda at the time Calvert published his work, and that these springs were still free from rust; but as they had not been exposed to damp with other springs not so treated, he was unable to deduce any opinion as to the advantage of the process. So it is generally. Practical men are continuously occupied with their work, and have unfortunately no time for experiments, though they suffer day after day from an evil the removal of which is probably within their grasp. ('Mechanical World.')

(24) To preserve iron from rust in Ceylon it requires to be first well scraped and cleaned; and if for outside work, such as bridges, roofs, girders, etc., it should be well coated with tar paint. The following receipt will be found to answer well, viz., coal-tar 9 gal., slaked lime 13 lb., turpentine or naphtha 2-3 qt. The use of the lime is for neutralising the free acid in the tar. This paint is very fluid, and well adapted for roofing, galvanised or black corrugated iron, etc.

(25) Too much stress cannot be laid upon the condition of the surface of the iron at the time of coating; and it is perfectly essential either to have a dry surface or else a composition which is not affected by water. Prof. Lewes remarks that when an old iron structure is broken up, on the backs of the plates may often be seen the numbers painted on them in white lead and linseed oil when the work was put together, and under the paint the iron is in a perfect state of preservation, the secret being that the paint was put on while the plates were hot and dry.

Compounds prepared with boiled linseed oil are open to objection on account of the presence of lead. The drying of boiled linseed oil is due to the fact of its containing a certain quantity of an organic compound of lead; and the drying property is, moreover, imparted by boiling it with litharge (oxide of lead), so that lead compounds are present even when the oil is not mixed with red or white lead pigment. When boiled oil dries, it does so by absorbing oxygen from the air, and becomes converted into a kind of resin, the acid properties of which also have a bad effect upon iron. Protectives of the class of tar and its derivatives, such as pitch and black varnish, and also asphalt and mineral waxes, are regarded by Prof. Lewes as among the best. Certain precautions, however, must be taken in the case of tar and tar products, both of which are liable to contain small quantities of acid and ammonia salts. If care is taken to eliminate these, and if it could be contrived to always apply this class of protectives hot to warm iron, the question of protection would be practically solved; bituminous and asphaltic substances forming an enamel on the surface of iron which is free from the objections to be raised against all other protectives—that is, of being microscopically porous and therefore pervious to water. Spirit or naphtha varnishes are condemned by Prof. Lewes as open to several objections. Varnishes to which a body has been given by some pigment, generally a metallic oxide, are preferable to the last class, if the solvent used is not too rapid in its evaporation, and if care has been taken to select substances which do not themselves act injuriously upon iron, or upon the gums or resins which are to bind them together and are also free from any impurities which could do it.

At the present time, as the author truly remarks, the favourite substance for this purpose is the red oxide of iron; but care should be taken to exclude from it free sulphuric acid and soluble sulphates, which are common impurities and extremely injurious. The finest coloured oxides are, as a rule, the worst offenders in this respect, as they are made by heating green vitriol (sulphate of iron), and in most cases the whole of the sulphuric acid is not driven off, the heat required being injurious to the colour. The acid is often neutralised by washing the oxide with dilute soda solution; but very little trouble, as a rule, is taken to wash it free from the resulting sulphate of soda, which is left in the oxide. The best form of oxide of iron to use for paint making is obtained by calcining a good specimen of hematite iron ore at a high temperature. When prepared in this way, it contains no sulphates, but a proportion of clay which is harmless if it does not exceed 12–18 per cent. Paint makers can easily test their red oxide for soluble sulphates by warming a little of it with pure water, filtering and adding to the clear solution a few drops of pure hydrochloric acid and a little chloride of barium solution. If a white sediment forms in the solution, the sample should be at once rejected.

In the application of a preservative coating to iron, Prof. Lewes directs, first, thorough scraping and scrubbing from all non-adherent old paint and rust. New iron should be pickled with dilute acid to get rid of every trace of mill scale; the acid to be neutralised afterward by a slightly alkaline wash, and this again to be washed off by clean water. Under these conditions, and given a composition of good adhering properties, but little apprehension need be felt with regard to the ravages of corrosion, the chief remaining risks being from abrasion or other mechanical injury to the composition, coupled with improper constituents in itself. ('Scient. Amer.')

Miscellaneous Receipts.—(*a*) *To Prevent Rusting.*—Boiled linseed oil will keep polished tools from rusting if it is allowed to dry on them. Common sperm oil will prevent them from rusting for a short period. A coat of copal varnish is frequently applied to polished tools exposed to the weather. Woollen materials are the best for wrappers for metals.

(*b*) Iron and steel goods of all descriptions are kept free from rust by the following:—Dissolve ½ oz. camphor in 1 lb. lard, take off the scum, and mix as much black-lead as will give the mixture an iron colour. Iron and steel and machinery of all kinds, rubbed over with this mixture, and left with it on for 24 hours, and then rubbed with a linen cloth, will keep clean for months. If the machinery is for exportation, it should be kept thickly coated with this during the voyage.

(*c*) *Anti-rust Varnish.*—Take the first three ingredients in a pounded condition, and digest them by a regular heat till melted, then add the turpentine very gradually, stirring all the while. Resin, 120 parts; sandarac, 180; gum lac, 60; essence of turpentine, 120. The mixture should be digested until solution, then add rectified alcohol, 180 parts. Filter through fine cloth or thick bibulous papers, and preserve in well-stoppered bottles or cases.

(*d*) *Removing Rust from Steel.*—Immerse the article to be cleaned for a few minutes until all dirt and rust is taken off in a strong solution of potassium cyanide, say about ½ oz. in a wineglassful of water; take out and clean it with a toothbrush, with some paste composed of potassium cyanide, Castile soap, whiting, and water; these last are mixed in a paste about the consistence of thick cream.

(*e*) *To Protect Iron and Steel from Rust.*—The following method is but little known, although it deserves preference over many others: Add 1¾ pints of cold water to 7 oz. of quicklime. Let the mixture stand until the supernatant fluid is entirely clear. Then pour this off and mix it with enough olive oil to form a thick cream, or rather to the consistency of melted and recongealed butter. Grease the articles of iron or steel with this compound, and then wrap them up in paper, or, if this cannot be done, apply the mixture somewhat more thickly.

(*f*) *To Protect Machinery from Rust.*—Dissolve 1 oz. of camphor in 2 lb. molten lard. Skin off the scum, then work in as much fine plumbago (black-lead) as will give it the colour of cast iron. Clean the machine and either smear with this, or apply warm with a brush. After a day the parts may be wiped clean by a soft fine cloth lightly applied.

(*g*) *To Protect Polished Surfaces from Rust.*—Melt some common resin in a pot and add a little olive oil. Remove the pot from the fire and add a little turpentine. Apply with a brush. The quantity of oil must be found by experiment, it being necessary that the coating, when cold, should adhere well, yet be slightly elastic so as not to chip off.

Lead.—Soft water, especially when full of air, or when containing organic matter, acts upon lead in such a way that some of it is taken up in solution, and the water is poisoned. Vitiated or impure air acts upon lead in a somewhat similar manner. Pure water, not containing air, does not act upon pure lead. When the water contains much oxygen, the lead is oxidised; and oxide of lead, a highly poisonous substance, is to some extent soluble in water. If there is much carbonic acid present it converts some of the oxide into carbonate of lead, which is almost insoluble, and therefore comparatively harmless. The waters which act most upon lead are the purest and most highly oxygenated, also those containing organic matter—nitrites, nitrates, and chlorides. The waters which act least upon lead are those containing carbonate of lime and phosphate of lime, in a less degree sulphate of lime. Some of these form a coating on the inside of the pipe which protects it from further action. Some vegetable substances contained in water, peaty matter for example, also protect the pipe, by forming an internal coating upon it. It appears therefore that hard waters, containing (as they generally do) carbonate of lime, do not readily affect lead. Soft waters, such as rain water, and water obtained by distillation—water polluted with sewage—water in tanks having a muddy deposit—may all become poisoned when in contact with lead. The mud of several rivers, even the Thames, will corrode lead, probably from the organic matter it contains, but it does not necessarily follow that any lead has been dissolved in the water. Bits of mortar will also corrode lead. Vegetables and fatty acids arising from fruit and vegetables, cider, sour milk, etc., also act upon lead.

(1) Prof. Emerson Reynolds has described a process for the protection of lead against corrosion, which is done by coating it with a film of sulphide of lead. He recommends the following method: Take 4 dr. solid caustic soda, dissolve it in 3¼ pints water, and add to the liquid 4¼ dr. nitrate of lead, or an equivalent of other lead salt, with 62 fl. dr. water; raise the temperature of the mixture to 194°F. (90° C.). If sufficient lead salt has been added, the liquid will remain somewhat turbid after heating, and must then be rapidly strained or filtered through asbestos, glass-wool, or other

suitable material, into a convenient vessel. The filtered liquid is then well mixed with 25 fl. dr. hot water, containing in solution 1 dr. sulphourea or thio-carbamide. If the temperature of the mixture be maintained at about 158°F. (70° C.), deposition of sulphide of lead or galena, in the form of a fine adherent film or layer, quickly takes place on any object immersed in or covered with the liquid, provided the object be in a perfectly clean condition and suitable for the purpose. When the operation is properly conducted, a layer of galena is obtained, which is so strongly adherent that it can be easily polished by means of the usual leather polisher. It is not necessary to deposit the galena from hot liquids, but the deposition is more rapid than from cold solutions.

(2) Dr. Percy observes that in the collection of the Museum of Practical Geology, in London, are a number of very thin sheets of lead, coated with bands of varied and extremely bright colours. Although the atmosphere has had free access to these sheets for about 30 years, the colours are as bright as they were at first. The sheets were prepared at Beaumont's smelting works, by dexterously skimming in the process of desilverising lead by Pattinson's process. The colours are certainly caused by excessively thin films of oxide of lead of various thickness.

(3) Applying an internal bituminous coating is said to be successful.

(4) Boiling for 15 minutes in a solution of sulphide of soda, by which the surface becomes coated with a film of sulphide of lead, insoluble in water.

Silver.—(1) To prevent silverware from tarnishing, it is only necessary to brush it over with alcohol in which a little collodion has been dissolved. It dries immediately, leaving a thin transparent invisible covering on the silver, which can be removed at any time by dipping the article in hot water.

(2) Silver paper. This is not the thin ephemeral-looking paper which the French are fond of calling *pelure d'oignon*, but a product discovered by a German pharmacist, and used, we are told, in some of the large towns for preserving silver from tarnish of all kinds. Six parts ordinary caustic soda are dissolved in sufficient water, and the solution is diluted to 20° B. To this solution four parts oxide of zinc are added, and the liquor is boiled until this oxide is dissolved. Sufficient water is now added to bring the solution down to 10° B. Thin paper or calico soaked in this solution and dried will effectually preserve the most highly polished silver from the tarnishing action of sulphuretted hydrogen, which is contained in appreciable quantities in the air of all densely-inhabited localities. Several journals have mentioned this preparation, but the exact manner of carrying it out is that given above from the German periodical in which it appeared. It is evident that not only silver objects may be preserved by this device for a considerable time, but scientific instruments made in other metals might be protected also during a long journey by sea or land from the oxidising influence of the damp air. All that is necessary is to wrap up the articles completely in the paper, so that no external air can come in contact with them. (Burgoyne.)

Zinc.—Damp air soon attacks zinc surfaces, but forms a film of oxide which arrests further corrosive action. Should the air, however, contain acid vapours, as it does in towns and near the sea, it is rapidly destructive. Soot is very injurious, forming a galvanic couple with the zinc, excited by the acid and watery vapour of the air. In contact with copper, iron, and lead, especially in the presence of moisture, voltaic action is also set up, and soon destroys the zinc. This metal is also much affected by lime, even in the form of chalky water; and by all acids, organic not excepted, hence it should not be joined to oak nor placed where urine may reach it.

◆

SAND-BLAST PROCESSES.

(*a*) THE sand-blast process consists essentially of some form of apparatus which sends a blast of sand from a suitable nozzle, this stream of swiftly moving sand particles, when directed against a glass, stone or metallic surface, having the effect of pitting or cutting the surface it strikes against. The sand is fired out of the nozzle either by compressed air or steam, and the sand is carried out with the stream or jet of air or steam so that the issuing blast resembles a small but severe sand storm. Compressed air is more generally used, as the high temperature of steam cannot be borne in many cases. For obscuring or frosting glass only a moderate strength of blast is needed, while with a strong blast granite and marble can be deeply engraved, scale removed from iron, and more difficult works effected.

Of course if the sand-blast is directed against a plain unprotected surface the whole of that surface will be acted on, therefore to form or engrave designs on a surface some protective agent must be employed to those parts which are not to be effected or "etched." It will be understood that the best protective agent to be employed is something that is more or less elastic, as such a substance is not easily eaten or worn away by the sand while the blast is doing its work on the unprotected surface. For glass, ordinary soft paper, like newspaper, is sufficient, a piece of this being cut out to the pattern required, and gummed or pasted on to the glass. The blast will then etch all the surface except where the paper is, so that when the paper is washed off, this part will be found clear glass. If the design is to be etched, then the paper is cut so that the design on the glass is left uncovered for the sand to act on. When a large number of pieces of glass have to be etched to the same design, then, so the writer is informed, a paper or metal stencil is cut and by means of this the design is put on the glass with quick drying paint (brunswick black), this being sufficient to protect the glass with the light blast used for glass etching. For stone or metalwork a tough elastic paper or cloth is fastened on to the surface as described with the newspaper on glass.

For a moderately strong continued blast, such as is necessary to cut away the coloured surface of flashed glass (to leave red letters on a white ground, with ruby flashed glass for instance), any ordinary paper can be made sufficiently resisting by previously coating it (on the side that the blast will act on) with a mixture of equal parts of ordinary hot glue and glycerine. This gives a good elastic surface.

The sand used must be what is known as "sharp." Sea-sand is unsuitable, for instance, as the constant motion has worn and rounded its sharp edges. Ordinary sand, if sharp, is quite suitable, and must be dry. It can be used over and over again until it is found to be losing cutting power. It does not require to be very fine. Crushed granite will serve the purpose, while emery has probably the greatest cutting properties of any commercial substance. The use of emery is referred to in describing the small etching appliance at the end of this article.

(*b*) *Cleansing Metals with the Sand-Blast.*—In large establishments engaged in galvanizing cast-iron without previous grinding, the use of the sand-blast in place of the circular wire brush has recently been introduced with great advantage. Articles with deep depressions, which cannot be reached with the scratch-brush, as well as small articles, which cannot be conveniently held in the hand and pressed against the revolving scratch-brush, can be brought by the sand-blast into a state of sufficient metallic purity for the galvanizing process. However, while the revolving scratch-brushes impart to the objects a certain lustre, they acquire by the sand-blast a matt lustre, and hence the blast is also frequently used for the purpose of deadening lustrous surfaces to their entire extent, or of producing contrast; for instance, matt designs upon a lustrous ground, or *vice versâ*.

The compressed air, whose pressure must be at least equal to an 18½ in. column of water, passes through the blast-pipe into a nozzle running horizontally, and carries away from there a jet of sand which falls into the outflowing blast, and is hurled upon the objects placed under the nozzle. The objects rest upon sheet-iron plates or in boxes of sheet-iron, which, moving at a slow rate, pass under the nozzle. To prevent dust the machine can be provided with a wooden or sheet-iron casing, a few windows allowing a view of the interior. The sand used in blasting collects in a box and is returned to the sand-reservoir by an elevator.

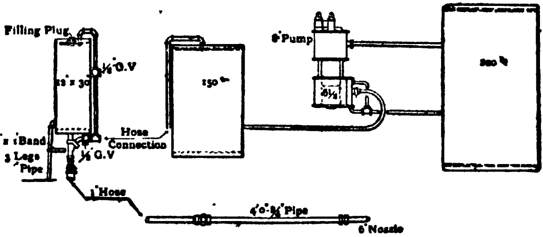


FIG. 22.

The jet of sand acts not only upon the upper side of the objects, which it strikes first, but also almost as energetically upon the lower, so that, as a rule, the cleansing process is completed by one operation. Articles of a specially unfavourable shape must be passed twice or three times under the nozzle.

(*c*) The question of painting locomotive tanks so that the paint will last and not scale is one to which our locomotive painters all over the country have given quite a little study, and many are the schemes and formulæ recommended for this class of work. It is admitted by all of them that if the scale and rust can be removed, and the paint applied to the clean surface, they will have very little trouble in making it hold, and it is also quite generally admitted that the most successful way to do this is with the sand-blast; but the question of getting a machine to successfully apply this sand-blast is one that has bothered a great many.

The sketches, Fig. 22, are designs used in the Aurora shops, and two years of experience have proved this arrangement to be practical, successful, and cheap.

At the left is an ordinary tank, portable, for holding the sand. This tank can be moved wherever required, as the air is supplied with a hose. The size of the tank can be varied to suit local conditions. The air is applied on top of the sand, and also at the combining nozzle to ensure a steady rapid flow of sand. The nozzle used is an ordinary piece of iron pipe, it being found cheaper to use a nozzle of this kind, and renew it a little oftener, than to make a hard steel nozzle which would probably last a few hours longer, as the sand in either case soon destroys the nozzle.

The success of a sand-blast depends, in a measure, on the velocity with which the sand can be delivered against the iron.

On the right is a storage reservoir, where the air from the compressor is pumped to 100 lb. pressure.

There is an ordinary 8 in. Westinghouse air-pump, and the air from the compressor runs this pump, and also delivers the air to the air-pump at 100 lb. pressure, being piped direct to the inlet-valves. By combining the air in this manner the pump will deliver the air to reservoir No. 2 at 150 lb. pressure, and this pressure in turn is delivered to the sanding apparatus on sand-tank. The size of the high-pressure tank can be varied to suit local conditions; but it is well to have this rather large, so that when it is desired to sand a tank, the air stored up will last for some time, as the pump will not be able to compress air to the high pressure as fast as it is used; but by having a large storage capacity, and having the tank charged before the work is started, we are able to sand-blast a tank very quickly.

After the tank has been very thoroughly sand-blasted, it has been found good practice to give it one coat of linseed-oil, and then wipe off as much of the oil as will come off readily, and allow it to stand for twenty-four hours, to be sure that it is fairly dry, and then apply the paint in the regular way. ('Railway and Locomotive Engineering.')

(*d*) The sand-blast is now put to many uses. One is the cleaning of ships' hulls, this method finding favour in our dockyards for this and other purposes. Constructional ironwork can also be cleaned very effectively by this means, if it is situated where the flying sand and dust are not objectionable. It will not only remove dirt, but also old paint if the pressure is sufficient. When tried in New York it was found that an air pressure of 20 lb. was sufficient, this being delivered through 300 ft. of 1½ in. hose, and, after passing through the sand mixer, issuing from a $\frac{3}{16}$ in. nozzle. Two nozzles cleaned 700 to 800 sq. ft. of surface per day. In cleaning the stone walls of a college, very effective work was done with an air pressure of 12 to 15 lb. per sq. in.

(*e*) A simple method of seeing the effect of attacking a glass surface with sharp grains of sand-like material can be tried by a home-made contrivance. It is a device much in the nature of a toy, yet in numberless cases a painter or glazier could use this means of etching a small piece of glass to match a broken piece, or for any special purpose. It is easier and quicker than the use of acid, or sending to a glass-workers' for a piece to be made.

Fig. 23 shows nearly all that is necessary to effect this. A box, like a cigar-box or a little larger, has the piece of glass tacked, or otherwise secured, as shown; the glass being previously painted with the design, or a piece of cut paper pasted on it, as described in (*a*) page 47. The parts of the glass which have no paper or paint on them and which are to be etched must be quite clean and have no gum or dirt on the surface. Now procure a small handful of ordinary lead shot, about No. 5 or 6, and about an egg-cupful of emery powder. This powder must not be too fine, but more the size of sand, like a fine sharp grit. Put the emery and shot into the box, close the lid, then shake the box up and down so that the shot will strike down on the glass. What first happens is that the emery gets embedded in the shot so that each shot becomes a

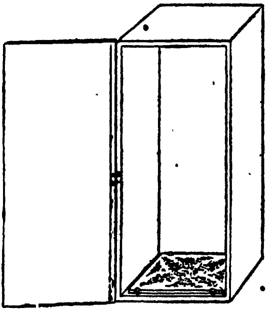


FIG. 23

small ball covered with fine emery points, and as soon as the shot is in this condition it will be found to have quite a rapid etching effect on the glass. From fifteen to twenty minutes shaking will be found sufficient for ordinary purposes. This simple apparatus can be used for metal if required. If the box lid does not shut soundly, the joint can have paper pasted over, though should there be regular use for it a proper dust-proof box could be made for the purpose.

SAWS.

SHARPENING, SETTING, PITCH OF TEETH, REPAIRS, ETC.

(a) IT is the practice of some men to set a saw and sharpen it afterwards while others reverse the two processes. In both cases good results are obtained, but the former practice is generally followed.

It is not as widely recognised as it should be that the sharpening and setting of saws is work requiring great practice and skill, for there are so many things, and some of them apparently so trifling, that go to make the saw work and wear badly. If, for instance, a saw is sharp and newly set, it will not work properly if the setting is irregularly done. The setting is perhaps of the greatest importance, yet if the sharpening is not done at a correct angle, the cutting will be bad and "wedging" result. The size of tooth and its pitch is governed by the work the saw is supposed to do. The dimensions are given a little further on, but it may be stated here that teeth of mixed sizes will not serve on one saw. The setting must be regular and not too great; on the other hand it must be sufficient. The greater the set the more work there is involved in sawing. It might therefore be argued that the least possible set would be best, but here the operator has to remember that the wear of the metal, in work, must be allowed for, this reducing the angle of the set by simple abrasion.

Setting.—The setting of a saw may be done in several ways. A professional saw-setter always uses a hammer and set-block, as these give good results in practised hands—hands (and eyes) that are unerring in affording just the needful blow and holding the saw at just the correct angle for accurate setting. Other tools are more favoured by the amateur, and it must be admitted that there are now tools to be had which leave little or nothing to be desired in obtaining accurate results. Their only fault is that they bend the teeth in operating, giving a more or less circular set, whereas the hammer blow carries the tooth over acutely or flat. The oldest form of saw-set is as Fig. 24, this being a steel plate with notches as shown, each notch being of a different gauge to take any thickness of saw. This is distinctly a bending tool, and, except in very practised hands, no two teeth will be bent to the same precise degree they should be.

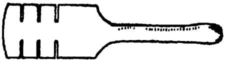


FIG. 24.

In setting by blows, the saw is laid nearly flat with its teeth along the ridge of a round-edged anvil held in a vice, of varying curve to produce an angle suited to the character of the saw, as Fig. 25. Alternate teeth are then struck in a most careful and uniform manner with a peculiar hammer as Fig. 26, the object of the blow being to bend every tooth in exactly the same degree sideways. When half the teeth have been so treated, the saw is reversed, and the second half are similarly served, only in the opposite direction. There is a risk of giving either too short or too long set: the former results in bending the tooth too sharply near the point, while the latter requires greater expenditure of force. Over-setting may be corrected by slight blows in the opposite direction. A very simple apparatus for bent setting may be made as shown in Fig. 27. It consists of a wooden framework *a*, carrying at the base a movable steel anvil *b*, each of whose eight edges may be chamfered to a different bevel. The framework also supports a steel punch *c*, free to slide up and down; the end of the punch is bevelled, the angle corresponding (there are eight punches) to the angle of the side of the anvil to be used, which varies with the kind of saw to be set. To set the saw, it is laid on the anvil with the teeth overhanging

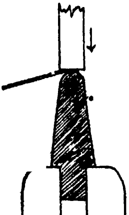


FIG. 25

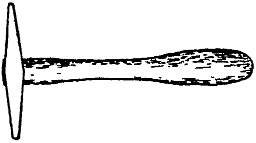


FIG. 26.

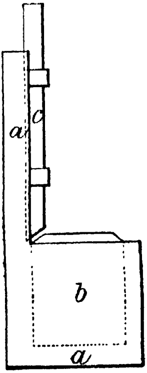


FIG. 27.

the bevel desired and under the line of fall of the punch, which latter is applied to alternate teeth in succession by striking it with a hammer. The advantage of the apparatus is that the amount of set given to each tooth must agree with the bevel of the punch and anvil. Fig. 28 is an ingenious set for fastening to a bench.

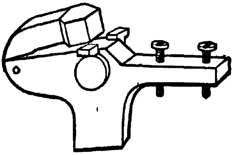


FIG. 28.

For setting by hand leverage there are several tools to be obtained, new designs being of frequent occurrence. Figs. 29 and 30 will serve to show the principle underlying most of them, the closing of a pair of handles causing a compressive force (much like a machine punch) to be exerted against each saw tooth when brought into a prepared space in the tool. The latter design is suited for every kind of saw and its operation may be described as follows:—

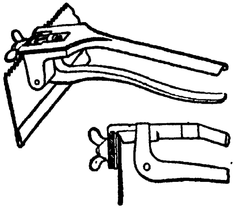


FIG. 29

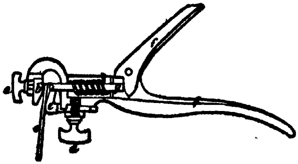


FIG. 30.

Hold the saw on any level place, teeth upwards. Place the set on the saw as shown. The anvil *b* is movable up and down, and must be regulated to suit the distance that the operator desires to set his saw teeth down from their points. Care must be taken not to have the angle or the point where the bend is made below the base of the tooth. The nut or the screw *a* fastens the anvil in any desired position. The guard *e*, when moved forward, increases the amount of set to be given; when moved back decreases it. The guard is made fast by the screw *d*. The set is operated by compressing the handles *f*, which carries the plunger *g* forward, and takes effect on the tooth of the saw *c*, as shown. Great care should be taken against setting saws too wide, as with too much latitude they will chatter and tear rather than cut, at a great cost of power and waste of material. All saws should be set or pressed into line three times to one filing, as by constant use the teeth wear off on the outside at their points, causing them to heat and spring out of true, thus spoiling the saws, burning the wood, consuming power, and retarding the work.

Filing.—Both hand filing and machine filing have their advocates. The former is generally more convenient, and may be rendered sufficiently regular by means of guides. The latter gives greater speed and regularity at less cost.

For hand-filing the first requisite is a "horse" or vice. Fig. 31 is an old form consisting merely of two strips of wood (which may be pine, but hard wood is better), about 3 in. wide and $\frac{7}{8}$–1$\frac{1}{4}$ in. thick, joined laterally by a wooden screw passing through both at one end, and having their upper outside edges chamfered off. The toothed edge of the saw stands sufficiently high above the clamp to allow the file to be used in a slanting direction without coming into contact with the clamp. The whole is held in a bench vice.

The more regular form of vice is as Fig. 32. The illustration shows the details, there being two jaws hinged at the bottom and, when closed, tightened by a cam handle. This vice has to be secured in a stand or in another vice.

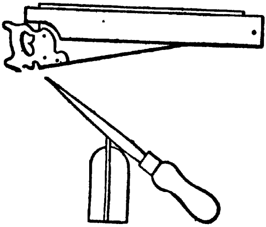


FIG. 31.

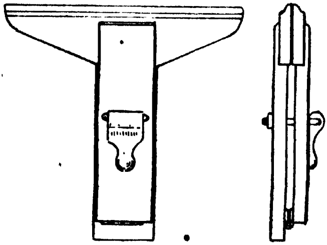


FIG. 32.

Fig. 33 shows a good form of vice suited for larger saws, yet being of service for small ones. This consists of two side frames, each carrying one jaw at the top, these frames being hinged on the bolts of the upper end cross-pieces. The lower cross-pieces are bolted at one end only, the other end acting as a latch to secure the whole when the saw is in between the jaws. By sloping the free ends of these lower cross-pieces, they are caused to tighten the jaws when they are pressed down in place with the foot. This is all plainly seen in the illustration.

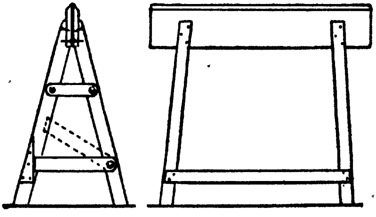


FIG. 33.

To reduce the noise occasioned by saw-filing, have a layer of leather or some folds of paper between the saw-blade and the jaws of the vice. The blade must be held tight, as any jar or vibration prejudices the work.

Jointing.—To put a saw in order, the first thing to be done is to "joint" the tops of the teeth, or render them uniform in length. This is termed "top-jointing" in straight saws and "rounding" in circular saws. To carry it out, Hodgson recommends the following cheap and expeditious plan. Procure a block of wood, say 6 in. long, 3 in. wide, 1 in. thick, dressed straight and true, then nail a similar piece on one edge, thus forming a corner in which to place a file. The file can then be held with the fingers, or be secured in various ways. Place the file flatly on the teeth, and press the larger block against the side of the saw blade, then file off the points of the longest teeth until the file just touches the extremities of the short teeth. It is important that the file be held in such a position that it will take off the points exactly at right angles with the blade, otherwise the teeth will be longer on one side than the other, which will cause the saw to deviate or "run" more or less. Grimshaw remarks that the operation is generally performed with a flat or "mill" file, although it may be done with a plane emery rubber or a whetstone.

"Side-jointing" is the term applied to a process for correcting irregularity in the set, or preventing undue side projection of any tooth; each tooth is thus made to do only its fair share of the work, and scratching or ridging of the sawn surface is avoided. It is most effective on swaged teeth, and is performed by a side file set in an adjustable clamp as shown in Fig. 34.

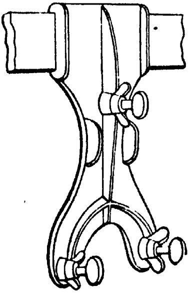


Fig. 34.

Filing Tools.—Very useful adjuncts to inexperienced workmen are the so-called filing guides, which determine the angle of contact and degree of force with which the file is applied. Fig. 35 shows a simple form, easily worked, and adapted to both straight and circular saws. The saw is held in the clamp *a*. On the guide is a circular plate *b* graduated to a scale for setting the file to a bevel for either side or square across the saw. Legs *c* extend from the plate over the clamp into grooves in the sides of the clamp. On the nether side of the plate *b* are a number of grooves corresponding to the scale on the edge, and into which a raised rib on the arched piece *e* engages, and is held in place by the thumb-screw *d* on the top of the plate. Through the ends of the arched piece *e* slides a rod *f*, to which are secured by screws the arms that carry the file *g*. By loosening the thumb-screw *d*, the file is readily changed to any desired bevel, and the handle of the tool may be lowered. When the file is set to the required bevel it is secured by tightening the thumb-screw *d*, and its pitch is regulated by a set-screw in the socket of the arm at the handle.

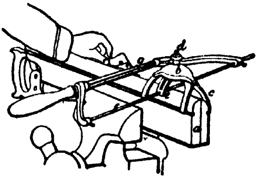


Fig. 35.

During the operation of filing, the rod governs the pitch and bevel, so that every tooth is equally filed. The machine is adapted for full, hollow, straight-edged, or circular saws. A table is issued with the machine, giving the correct bevels and pitches for the various kinds of saw to be filed.

Elkin's patent saw sharpener, Fig. 36, enables any person to accurately and quickly sharpen any straight saw, including rip, cross-cut, buck, band, jig, etc. It is a combination of clamps and adjustable guides, by means of which the saw can be firmly clamped and correctly sharpened. The adjustable guides can be so marked as to give the tooth the same bevel, pitch, and elevation. The machine is simple, strong, and durable in construction, It only occupies a space in inches of 16 by 3 by 3. For use, secure it to a bench with two screws, place the saw in the clamp, with the teeth just above the face or upper part of the jaws—the handle to the right. The rod, upon which the travelling plate slides as each tooth is filed, can be secured at any desired elevation by means of the thumb-nuts at the ends. Having obtained the elevation, the file is brought across the saw at an angle corresponding with the bevel of the tooth, and there made fast by turning the thumb-screw beneath the travelling plate. In order to get the correct pitch of the tooth, the loose bushing, through which the file carrier passes, must be perfectly free, and by pressing the file down between the teeth, you have the pitch. This bushing is held in its proper position by a set-screw. Always file from the handle toward the point of the saw, and never press down upon the file when it is being drawn back. Having filed one side of the saw, it should then be reversed with the handle at the left. Then swing the handle of the file to the left, bringing the file across the saw to the correct bevel. The pitch of the tooth is again to be obtained as before.

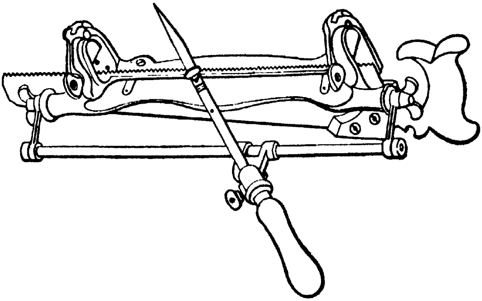


FIG. 36.

The files employed for sharpening saws include flat ("mill"), triangular, round (for gulleting), and special shapes, varying of course in size and in grade of cut. The width of the file should always be double the width of the surface to be filed. Preference is given to files in which the grade of the cut (distance between the teeth) increases progressively from point to heel; with this exception, hand-cut files are esteemed superior to machine-cut. For small teeth at 60° it is convenient to use a file which will sharpen the back of one tooth and face of the next at the same time. "Float" or single-cut files are the best. Double-tapered triangular files are not to be recommended; when used, they should have a button at the point end. Files for band-saws are made with rounded angles to suit the gullets of the teeth. Order and regularity in filing are essential. Common rules for filing are: (1) File the faces before the backs; (2) if the teeth are to be square, file in regular succession—1, 2, 3, 4; (3) if they are to have fleam, file 1, 3, 5, 7, to right, and 2, 4, 6, 8, to left; (4) file the fronts of all teeth set from you, and the backs of those set towards you. (Grimshaw.)

In sharpening saws by means of emery wheels, the speed of the wheel has great influence on the cutting action. The coarseness or fineness of the grit composing the wheel must be suited to the nature of the work. The average speed of periphery adapted for most purposes is 4500—6000 ft. per min., the slower speed being for wheels of 12 in. diam. and less. These wheels are only employed satisfactorily on large circular saws.

Saw-Teeth.—A saw consists of 4 parts—face, point, back, and gullet or throat. Teeth vary in spacing, length, angle, rake, set, fleam, and form of gullet. A saw blade may contain several kinds of teeth in succession; but all teeth of a kind must be either quite uniform or arranged in a regular order of change.

The following table includes saws generally used by mechanics who work wood by hand :—

Names.	Length in Inches.	Breadth in Inches.		Thickness in Inches.	Teeth to the Inch.
		At Handle.	At End.		
Without Backs.					
Rip-saw	28–30	7 –9	3 –4	0·05	3½
Fine rip-saw . . .	26–28	6 –8	3 –3½	0·042	4
Hand-saw	22–24	5 –7½	2½–3	0·042	5
Cut-off saw	22–24	5 –7½	2½–3	0·042	6
Panel-saw	20–24	4½–7½	2 –2½	0·042	7
Fine panel-saw . . .	20–24	4 –6	2 –2½	0·035	8
Siding-saw	10–20	2½–3½	1¼–2	0·032	6–12
Table-saw	18–26	1¾–2¼	1 –1½	..	7–8
Compass or lock-saw .	8–18	1 –1½	½–¾	..	8–9
Keyhole or pad-saw .	6–12	½–¾	⅛–¼	..	9–10
With Backs.					
Tenon-saw	16–20	..	3¼–4¼	0·032	10
Sash-saw	14–16	..	2½–3½	0·028	11
Carcass-saw . . .	10–14	..	2 –3	0·025	12
Dovetail-saw . . .	6–10	..	1½–2	0·022	14–18

(Holtzapfel.)

Band-saw teeth should have a tooth space equal to ½ the width of the blade for soft wood, and ⅓ for hard, while the depth of the tooth in each case should be ⅓ the width of the blade.

The length of tooth is governed by the hardness of the wood, the longest teeth being best adapted for wet, fibrous, and soft woods, as giving greater clearance; but more care is needed in having a moderate and regular set.

The angle of saw teeth may vary between about 60° and 40°. The fundamental angle is 60°. This may be in the form of an equilateral triangle for hard and knotty wood, but for soft wood it is better that all the pitch should be on the cutting face—an upright edge with sloping back. For varied work the usual angle is 40°, the pitch being equally divided. Teeth of any angle but 60° are not so readily filed with an ordinary file.

The degree of rake may increase in proportion to the softness of the wood; in hard woods it causes a tendency to spring in. It may also be greater in a circular saw on account of its greater speed. Fig. 37 (from Grimshaw) shows various degrees of rake, the arrows indicating the direction of the strain.

The set of a tooth may be either "spring" (bent) or "swaged" (spread). The former cut only on one side, have more tendency to spring in, and are more subject to side strains; the latter cut on both sides, unless they are sheared, and they are less liable to spring in and suffer from side strains. The more gummy the wood, the greater set is needed. Circular saws require more set than straight ones.

The fleam or side angle of the teeth varies from 80° or 90° horizontally for hard woods, to 60° or 70° horizontally and 30° or 35° vertically for soft. It is most effective in the case of soft woods free from knots; and should not accompany a bent set, as both aggravate the tendency to spring in.

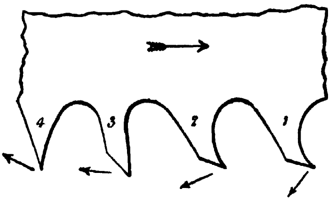


Fig. 37.

The gullet or throat should always be rounding and never square, as the latter condition gives a tendency to crack. Fig. 38 (modified from Grimshaw) shows when the gullet requires deepening, by a process known as "gumming." The tooth *a* is in perfect order; *b* is still capable of doing good work; but *c* demands gumming. The higher the speed and the faster the feed, the greater the necessity for rounding the gullet, especially in band-saws. Spaulding's rule for finding the amount of gullet in sq. in. per tooth for circular saws is to double the number of cub. in. of wood removed at one revolution, and divide by the number of teeth. Insufficient gullet causes choking, heating, and uneven running.

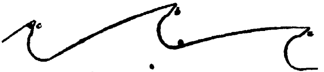


Fig. 38.

The depth, fleam, hook, and rake of teeth may increase in direct proportion to the softness of the wood; the spacing and depth of gullet should be augmented for fibrous and porous wood; thin blade and slight set are desirable for costly wood; a thick blade is demanded for hard wood.

(*b*) The operations entailed in keeping a saw in working order are threefold—filing, setting, and gumming. These will be described in succession.

First of filing. It is a great deal easier to keep a saw sharp by frequent light file touches than to let it get so dull as to need a long-continued filing down, after it gets so dulled as to refuse to work. The saving in power, by using a sharp saw, is very great. Thinner blades may be used than where the teeth are dull; because the duller the saw, the more power required to drive it through the wood, and the more strain on each tooth separately, and on the blade as a whole. For the same reason, longer teeth may be used where they are sharp than where they are dull. The advantage of using sharp teeth is greatest in those saws in which the strain of cutting tends to deform the blade—as in all "push cut" straight saws and in circulars. (Grimshaw.)

(*c*) The saw, secured in a proper clamp, should be placed where a strong light will fall on the teeth, so that the filer can have the full advantage of all the light he requires. Should there be a deficiency of light the filer should provide a good lamp, and place a dark shade between the light and his eyes, so that he can see at a glance when every tooth is filed to a complete point. One careless thrust of the file, when a tooth is filed enough, will do a saw more harm than can be repaired by ½ hour's filing. A beginner should always take a try-square and the sharp point of a small file, and make a hair-mark from the point of every tooth at a right angle with the teeth on the sides of the blade. This should be done when the points of the teeth are all at a uniform distance apart. Such marks will enable the filer to keep the face of every tooth dressed at the most desirable angle. These directions, however, are only applicable to saws intended for cross-cutting. Beginners must always exercise unusual care when filing the back of each tooth that has been finished. After the teeth are filed to complete points it is an excellent practice to go over them carefully with a half worn-out file, for the purpose of bringing the points to a more perfect cutting edge. (Hodgson.)

Gumming.—Gumming consists in deepening the throat or gullet of a saw, and is effected by means of punches, or preferably by rotating steel cutters or emery wheels. Too often the gumming is neglected, more of the face of the tooth being filed away instead, thus reducing the diameter of the saws and causing waste.

According to Duncan Paret, the simplest method by which solid emery wheels can be applied for saw gumming is by placing them on the spindle of the circular saw. The saw to be gummed can then be laid on the saw table, or supported in any convenient way. A simple way is to pass the end of a rope with a small cross stick on it through the eye of the saw, and thus suspend the saw so that it swings evenly balanced just in front of the emery wheel. The weight being thus carried, the operator only has to use his hands to guide the saw against the wheel. Where expensive machinery is scanty, and where people are slow to introduce the latest improvements, there is a steady demand for saw-gumming wheels 14–24 in. in diameter. Where the latest improvements are quickly added, regardless of price, nearly all the emery wheels used for saw gumming are 12–8 in., none of the machines specially designed for saw gumming being intended to carry anything above a 12-in. wheel. Emery wheels are unfavourably contrasted with grindstones as causing a heating of the saw, but this can be obviated by using the wheel under a small constant stream of water. One advantage of a rotating steel-cutter gummer over an emery wheel is that, whereas an inexperienced hand can ruin a saw by case-hardening with an emery wheel, this cannot be done with a steel-cutter or "burr gummer." Most of the emery gummers for circulars require that the saw shall be taken off its arbor to be gummed: all burr gummers work with the saw in position. (Grimshaw.)

(*d*) The order followed in renovating the cutting edge of a saw should be (1) gumming, (2) setting, (3) filing; but as the last named is often the only kind of attention the saw receives, it has been described first.

(*e*) Having discussed the general principles on which the renovation of saw teeth is based, and detailed the manner in which the operation is conducted, a few illustrated examples may be given of the teeth of the chief kinds of saws in use (see Fig. 39).

Hand Saws.—(1) Cross-cut saws (hand) vary from 12 to 32 in. in length. Their tooth edge should be straight or a trifle bulged in the middle. The teeth should be fully set and well jointed. *a* shows the best tooth for cutting soft wood; *b* is better adapted for wood of medium hardness and for mitreing soft wood; *c*, for harder wood, has the back of the teeth filed square. For cutting timber the teeth are made much larger, but resemble those in *b*, the set being increased with the wetness of the wood. The long cross-cut saw for two men is toothed as at *i*, the cutting edge of the saw being appreciably highest in the middle and gradually tapering towards each end; the bevel shown is adapted to soft or wet wood, and must be lessened for harder or drier material. *k* represents an American hook tooth, which is based on the principle that while the fleam teeth or knives are cutting into the wood, the hook teeth remove the "dust." These saws work easily and cut rapidly. The rake of a cross-cut saw is at the side. It takes less inclination than the cross-cut. The cross-cut requires finer and more particular filing than the rip or web saw, and cannot be considered well filed unless a needle will travel down the angular groove which is formed by the line of alternating points of teeth seen in all well-filed saws. When the teeth are so regularly formed that a needle will travel from end to end in the angular groove, and the points are sharp and keen, the saw will cut a kerf in the wood that will have a flat bottom. The last teeth of cross-cuts may be rounded at the points, to prevent tearing the wood when entering and leaving the cut.

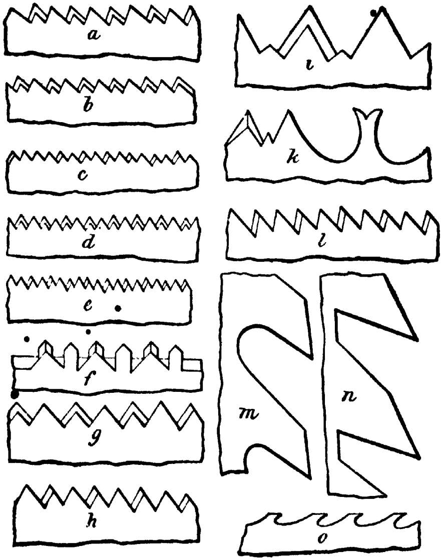


Fig. 39

(2) Back-saws are shown at *d* and *e* (Fig. 39); the former suits soft wood, while the latter is for harder wood and for mitreing. The thinness of the blade of the back-saw is compensated for by the stiff back, which must be kept tightly in place.

(3) The fleam tooth is illustrated at *f*. It is only adapted for very clean soft wood, which it cuts rapidly and smoothly. It has no set, and is filed while lying quite flat.

(4) Buck-saws are represented at *g* and *h*, the former being for wet or soft wood, and the latter for dry or hard.

(5) Web, scroll, and compass saws are best provided with teeth as shown at *l*, for whilst they have to perform both ripping and cross-cutting, a tooth adapted for the latter will perform the former operation, though more

slowly, but the converse rule does not hold good. Finer teeth will be necessary for hard wood. The backs of all saws of this class are made very thin, to avoid the necessity for giving a set to the teeth.

(6) The rip-saw, for cutting wood longitudinally, requires an essentially different tooth from the cross-cut. For a vertical mill-saw, the best form of tooth is that shown at *m*, the edge of each tooth being spread out by means of the crotch-punch. An inferior-shaped tooth is seen at *n*, the setting being on one side of the tooth only, taking opposite sides in succession. *o* illustrates the best form of tooth for a hand rip-saw, the action being precisely like that of a mortice chisel. The rake of a rip-saw is in front. It takes more inclination than a cross-cut. The points of the teeth should be trued with a straight-edge, as, in general experience, a rip-saw does more work, with greater ease, straight, than when either rounding or hollow on the cutting edge; some good workmen, however, prefer rip-saws slightly hollow, not more than ⅛ in. in the length of the blade. The hand rip-saw is usually a few inches longer than the cross-cut, but has far fewer teeth. Rip-saws are often given too little rake and gullet. The first 6 or 8 in. at the point of a hand rip-saw may have cross-cut pitch, to allow of cutting through knots without having to change the saw for a cross-cut.

Circular Saws.—(7) Circular-saw teeth generally have greater space, angle, and set than the teeth of straight saws. They should be filed on the under side; widely spaced, very hooking, and with plenty of gullet to let out the chips. Teeth of circular saws can be gauged to exact shape by having a piece of sheet steel cut out to fit. Absolute likeness in all respects can be controlled by having a piece of sheet metal cut to the required outline and attached to an arm forming a radius of a circle from the shaft carrying the saw. Three light filings are preferable to one heavy. The shape of under-cut teeth is apt to be altered in filing. The flaring sides of M teeth require special files. When a tooth is broken so as to be only slightly short, it can often be brought out to line by using the crotch-swage as a lever while hammering upon it. The saw should always be allowed to run free for a few minutes before removing it from the shaft. Circular saws should always be either hung up in a free perpendicular position, or laid quite flat. Fig. 40 shows a series of circular-saw teeth of varying shape and rake. The softer the wood, the greater rake admissible. In some cases (*b*, *c*) the back rake tends to reduce the acuteness. *c* is recommended for ripping hard wood in winter; *c*, for hard wood in summer; *g*, for all kinds of wood in summer; *b*, *c*, for harder woods than when no back rake is given; *f*, with a rounded gullet, 2 in. long for soft wood, 1¾ in. for hard; *h*, *i*, *j*, *k*, *n*, are forms of ripping teeth little used in soft wood; *l* is popular in Europe; *m* is a cross-cutting tooth, very liable to break on a knot in frosty weather. The question of few or many teeth in a circular rip-saw depends almost entirely upon the character of timber being ripped; and the feed per revolution should be made dependent upon the strength of the teeth to resist breaking, and the capacity of the gullet to hold the cuttings. In a cross-cut the conditions are different.

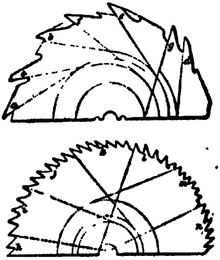


FIG. 40.

To straighten a circular saw, get a hard-wood block 12 in. by 12 in.; bed it on end on the ground (not floor); round the top off with ¼ in. rise; nail up a joist at the back of the block for the saw to rest on; let its face be an inch below the top of the block. Use a 3 or 4 lb. blacksmith's hammer for saws over 50 in.; a lighter one for smaller and thinner blades. For large saws, the straight edge should be about $\frac{1}{16}$ in. thick, 20 in. long, 3½ in. wide in centre, 1 in. at end; the edge of the straight side chamfered or rounded off. Balance the saw on a mandrel, and apply the straight edge; mark the high places with chalk; have a helper to hold the saw on the block, and hammer on the humps, testing frequently. (Grimshaw.)

When a saw is not round, the defect may be corrected by adopting the following directions: Take a piece of grindstone or a cobblestone and hold it against the points of the teeth while the saw is revolving, and thus reduce or wear down the most prominent teeth; or a piece of red chalk may be held against the points, which will mark them in proportion as they are long or short, when the long teeth are reduced by filing. Circular saws sometimes burst from what appear as unknown causes. There can be no doubt when a saw does fly in pieces that a thorough investigation would trace the occurrence to one of the following causes: (1) Square corners at bottom of tooth; (2) Out of round, with the backs higher than the points, so that instead of cutting they scrape the dust off with the back; (3) Undue strain put upon the saw by the plate rubbing against the timber, causing it to heat, which takes the life out of a saw. In a recent report of the French Society for Preventing Accidents from Machines, a recommendation is made for the avoidance of the use of circular saws in workshops where practicable. The following are the reasons for this recommendation: (1) Circular saws are dangerous to workmen; (2) they require more power than other saws; (3) they cut a broader line, and are consequently more wasteful.

The speed of circular saws varies with the size, as follows: 8 in. diam., 4500 rev. per min.; 12 in., 3000; 16 in., 2200; 20 in., 1800. The speed for cross-cutting can be increased with advantage 1000 ft. beyond those used for ripping, say to 10,000 ft. per min. Never cut stuff that measures more than ⅛ the diameter of the saw. The manner in which a circular saw is hammered has much to do with the speed at which it can be run, and often when a saw becomes limber and "runs," it is the fault of the hammering instead of the speed. When slack on the periphery it will not stand speed, and becomes weaker and bends more readily when in motion than when it is still; on the contrary, if it is properly hammered, a little tight, as it is termed, on the periphery, it becomes more rigid when in motion up to a certain limit. The theory of this is that the steel is elastic, and is stretched by the centrifugal strain in proportion to the speed, which is greatest on the line of teeth, and diminishes to the centre. If saws evince a tendency to spring and a want of rigidity, have them rehammered at once, before changing the speed in an endeavour to remedy the defect.

Band Saws.—(8) The band-saw is never used for cross-cutting, except when cutting scrollwork, and may generally be treated as a rip-saw. It requires special regularity in shape and set of teeth to prevent it from breaking and from running into the work. In order to set up a jointed band-saw, the two tongues are introduced simultaneously into the two corresponding openings, and the ends of the saw are pressed together laterally, in such a manner as to cause the snugs on the tongues to engage with or hook on to the bevelled edges in the openings, and the thin ends of the tongues then lie in the inclined recesses in the sides of the saw. When the parts are in this position, the two extremities of the saw cannot be separated either by a considerable strain in the direction of its length or by a diminution of the tension. To disconnect the ends of the saw, separate the hooked and bevelled edges by applying lateral pressure, and at the same time draw the ends apart in opposite directions. The junction of the two extremities is effected by means of a hook or interlocking joint. A portion of the saw near each extremity is reduced in thickness in such a manner that, when the ends are laid together, the two combined do not exceed the thickness of the remaining part of the saw. Portions of the back and front of the extreme ends are also cut away, so as to leave narrow tongues at each extremity of the saw, and these tongues are provided on opposite sides relatively to each other with snugs or hooks. In the thin portions at the extremities of the saw there are formed, at equal distances from the tongues, two longitudinal slits or openings, presenting bevelled or inclined surfaces at the edges nearest the ends of the saw, corresponding exactly to the snugs on the tongues. The opposite edge of each opening is also bevelled or inclined, but at a much more acute angle, so as to form a recess in the side of the saw for the reception of the extreme end of the corresponding tongue, which is suitably reduced in thickness towards the extremity, in order to enable it to be well within the said recess.

Where gas is used for lighting purposes, it is often employed for brazing band-saws, and nearly in every case where this is done the blade of the saw operated upon deteriorates, and breakages gradually increase. As these breakages do not occur exactly at the joint no blame is attached to the use of gas, and the cause of continual failures is rarely discovered. A gas flame not only scales steel deeply, but also destroys its nature by burning the carbon out, and this occurs especially at the edge of the flame. Band-saws brazed by gas almost invariably break again at a point some little distance from the previous fracture, at the point where the outer edge of the flame has damaged the metal. The only really satisfactory way of repairing is to make a thick, heavy pair of tongs bright red hot, and clamp the joint with them. The heat melts the spelter instantly, and makes a good joint without scaling or damaging the steel. The process is to first file the ends of the saw on opposite sides so as to form two wedge-shaped ends for the length of two or three teeth. The saw should then be secured on a rest or holder in perfect line, with one end lapped over the other. Damp the ends to be joined, and place between the lap a small quantity of brass spelter with a little powdered borax; heat a pair of tongs to a bright red, scrape off all scale from the jaws, and close the tongs tightly on the ends to be joined. When the spelter is melted, slip off the red hot tongs, and slip on a pair of tongs that have been warmed. Close these tongs very tight on the joint, and remove when the spelter has properly set. Now hammer the joint lightly, and file to uniform thickness with the rest of the saw-blade.

For a joint which has to stand constant heavy strains and bending it is better to use an alloy of equal parts of coin-silver and copper, melted together and rolled out thin. This alloy never burns, cannot be overheated, and makes first-rate joints, which will stand hammering and bending to almost any extent. An excellent special solder, apparently with silver in its composition, is that made by J. and C. Phillips, College Hill, London. It is called the "Titan" saw-brazing tape, it being made as a thin riband and sold in 1 oz. reels. This firm also has a good form of band-saw brazing tool outfit, as illustrated by Figs. 41 and 42. It is suited for brazing any description of band-saw. It is provided with planed surfaces with set screws and springs for holding saw in place whilst being brazed and is held in any vice as shown. The method of using is as follows: The band-saw to be brazed, after having its extremities thinned down so that a lap joint can be formed, and care taken that the total thickness of lap is not greater than the blade itself, is covered with a mixture of brass solder and borax, in a moist state. The tongs are then heated to a good heat and closed upon it. It is necessary to slacken a thumb-screw to allow for expansion after the tongs are closed upon the joint. After cooling the joint, dress with a hammer, make it of even thickness, and set the teeth.

The working action of a band-saw is, generally speaking, simliar to the working action of a circular saw — continuuous. Owing chiefly to the thinness of the gauge, the small area of the blade which operates on the wood at one time, and the constant cooling action which is going on as the saw passes through the air, a comparatively small amount of heat is engendered; the saw, therefore, can be run at a considerable speed without detriment. On machines in which the saw-wheels are of small diameter, say below 36 inches, and where the arc of contact of the saw on the wheels is necessarily more acute, the speed of the saw-blade should not much exceed 4500 feet per minute for all ordinary kinds of sawing. With saw-wheels above 36 inches diameter, this speed may safely be increased up to 6000 feet per minute; this is, however, on the supposition that the top wheel is of the lightest construction, and is mounted elastically, i.e., has a spring or other adjustment to allow for the expansion and contraction of the saw-blade. There is no advantage in running band-saws beyond 6000 feet per minute, as the risk of breakage is increased without affording any corresponding gain. In sawing hard woods the speed should be reduced. The band-saw may be said to have a blade of superior thinness, capable of tension in varying degrees, moving in right lines through the material at a speed that is almost unlimited and can exceed that of circular saws, operating by machinery consisting only of rotating parts and of the most simple construction, the saw-dust all carried down through the timber and offering no obstruction in following lines and peculiar adaptation to curved lines.

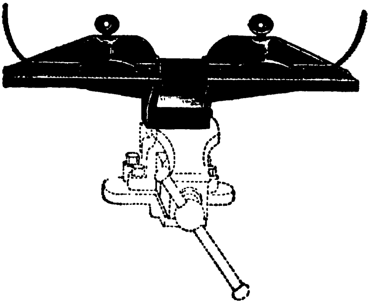


FIG 41.

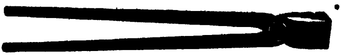


FIG. 42.

"The speed of sawing, or the cost of sawing, which is much the same thing as the movement of the teeth, is with the band-saw almost unlimited. Its performance, contrasted with jig-saws for cutting plain sweeps or scroll-work, shows a gain of time or cost of 3 to 1, with the important advantage of being easier to operate, and much more popular with workmen. The greatest objection to a band-saw is that it cannot be used for cutting inside work. Some workmen saw clean through the stuff to get at the inside, when the nature of the work will admit of such treatment without weakening or injuring the design. Strips of the same kind of wood as the design are firmly glued into the saw-kerfs when the work is completed. Of course, this method of reaching inside cutting can only be adopted where the design is not intended to bear any strain. Many devices have been suggested for separating and joining band-saws, but most of them are unavailable or impracticable. One, however, enables the operator to separate the saw, pass it through a hole bored in the wood, and join it again in less time than it takes to disconnect the blade of a jig-saw, pass it through the wood and connect it again to the machinery. This arrangement gives the band-saw an important advantage over the jig-saw in its own special province, as it renders it possible for much thicker material to be sawn than could be done with the jig-saw, and the work will be better done in less time." (Powis Bale).

(*f*) Though the saw is by far the most important of any of the carpenter's tools, how often we see a carpenter almost work the very life out of himself with a saw in bad shape, and yet not do even a fair day's work. Again, how often we see mechanics leave an inside job (where the lumber was dry) with their tools in good order, and go to framing coarse, wet, cross-grained lumber. Their saws would cut fine until they got in a little way, and then, as they would not be set enough for that kind of lumber, the saw would bind, and it would be almost impossible to continue to push it until the piece was cut, simply because there did not happen to be a set on the job.

How easy these hard, unsatisfactory days could have been made by simply laying the saw down on some studding or joists on the trestles, as shown in Fig. 43, and set with a common nail-set, which would practically not dull it at all.

A common nail-set makes the best saw-set I know of to meet the emergency just mentioned. Many claim that a hammer set is the only perfect set, while I find for general use the latest hand sets much more convenient.

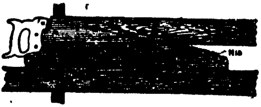


FIG. 43.

Fig. 44 shows the set in a saw, which should always be just as little as possible and have the saw run free.

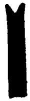


FIG. 44.

Fig. 45 is a rip-saw, which should be filed square across for all ordinary work. The set gives all the bevel the teeth need, as rip-saw teeth should march one after the other just like little chisels, and cut clear across the tooth and not simply cut on the outside edge as a cross-cut saw, which acts more like knife blades on each side of the saw.

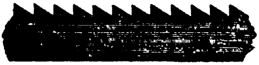


FIG. 45.

Fig. 46 shows the "jointing" of a saw which is generally done with a flat file. A cut-off saw should be jointed rounding, while a rip-saw should be jointed perfectly straight, although many of them are jointed rounding, and some joint them hollowing.

FIG. 46.

Fig. 49 illustrates a good way to file a cut-off saw that has got into very bad shape. After the teeth are all made even and the same pitch (or rake), then give it proper bevel.

FIG. 47.

Fig. 48 shows a saw filed with about the right pitch and bevel for ordinary hard wood.

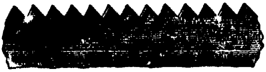


FIG 48.

Fig. 49 shows the proper pitch, bevel and fleam, which is the bevel on the back of the tooth, for ordinary soft wood. It also shows the file, which, as you will note, should point towards

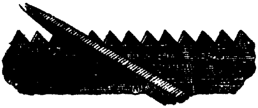


FIG. 49.

the point of the saw. Not only is that my opinion, but all the best authorities I have ever read on the subject give it the same way. Still, I am free to admit many good mechanics file just the other way.

Fig. 50 gives the degree of pitch. Tooth and the dotted lines show that the rip-saw tooth should be on the square, or at an angle of 90°. I used to file even just a little sharper than that. Tooth 2, which is 60°, is right for a general cut-off saw. If you wish the saw to cut fast, though possibly not quite as smooth, file it 70° or more like tooth 3, while 4 shows a tooth 80° or over, which is about right for a compass saw that rips as much as it cuts off, or any similar saw, such as a rip-saw for cross-grained hardwood where it has to do some cutting across the grain, or a cut off saw for sawing diagonal sheathing, or rafter cutting, which is as much ripping as cutting off.

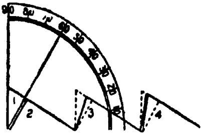


FIG. 50.

Fig. 51 is looking right down on to the edge of the saw, and shows that the rip-saw should be filed square across or at an angle of 90° with the saw, while a strictly cut-off saw at an angle of 45°, and for the different classes of work the file should swing at different points between 90° and 45°.

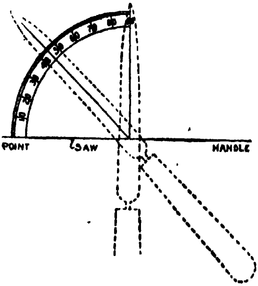


FIG. 51.

Fig. 52 shows how the file should be held level for rip-saws, and some even hold it level for all saws, and others drop the handle so the point is raised to about 30°. I seldom raise the point of my file more than 10°.

Anyone who is willing to give the time required to keep a saw in good order (and that time is time well spent) ought to be interested enough in his saw to secure a good one, even if it does cost a little more. A cheap saw is a poor investment at any price, for the files and time it takes to keep it in order would soon pay for the very best.

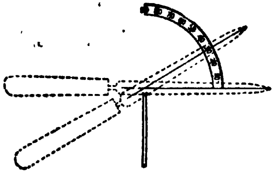


FIG. 52.

While there have been no radical changes in saws in my time, yet there have been some improvements, the main improvement being in the perfecting of the steel, until to-day we have silver-steel, which stands at the head. The perfection handle, which is shown in Fig. 53 by the main lines, is also an improvement, while the dotted lines show the old style. The perfection handle is hung, as you will notice, more on to the saw, and places your hand nearer your work; this makes the saw hang better, and makes your day's work easier. (Dwight L. Stoddard, in 'American Carpenter and Builder.')

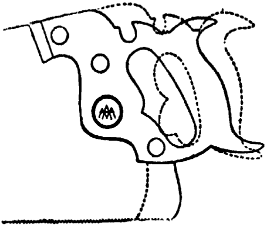


FIG. 53.

(g) Considerations governing the Shape of Saw-teeth.—A consideration of the action of the saw in cross-cutting timber settles the cutting edge, and the mode of sharpening. Taking our ordinary cross-cutting single-handed saw as the type, the forward thrust is intended to separate the fibres, and this not in the way of driving a wedge, but in the actual removal of a small piece by two parallel cuts. For example, if ○ ○, Fig. 54, be a fibre, then the action of the saw must be to cut clean out the piece *a*, *b*, so making a space *a*, *b*, wider than the steel of which the saw is made. The cleaner the cuts *a d*, *b c* are, the better. Now this clean cut is to be made by the teeth advancing toward the fibre. If they come on in axe fashion, then the separation is accomplished by the direct thrust of a sharp edge, in fact, by a direct wedge-like action. Now a wedge-like action may be the best for separating fibre adhering to fibre, but it is an action quite out of place in the cross-cutting of a single fibre, in which cohesion has to be destroyed. There is needed a cutting action, i.e., a drawing of an edge, however sharp, across the mark for separation; this drawing action is very important. Admit for the present that such action is essential, then the saw-tooth as constructed does not supply it. Clearly the sharp edge must somehow or other be drawn and pressed as drawn across the fibre. Two ways of accomplishing this present themselves. The effect on the action of the workman is very different in these cases. In the first we must press the saw upon the fibre, and at the same time thrust it lengthwise. Now in soft timber, and with a saw having teeth only moderately sharp, this pressure will tend rather to force the fibres into closer contact, to squeeze them amongst each other, to solidify the timber, and increase the difficulty in cutting. Two actions are here, pressure and thrust. In the second case the pressure must be very light

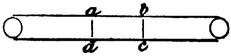


FIG. 54.

indeed ; if otherwise, the point of the tooth will gather up more fibres than the strength of the workman can separate ; indeed, as a rule, in the cross-cutting of broad timber, with all the saw teeth in action, pressure is not required, the average weight of the saw-blade sufficing for the picking up of the fibres. It is probably from the delicate and skilful handling which a tooth thus constructed requires that hand-saws are not more generally constructed with teeth of this form. In addition to these there is the penetrating tooth, as the points of the peg tooth and others. Whatever may be the form of the teeth, the small piece *a b*, *c d*, Fig. 54, has to be removed so as to leave the ends from which it is taken as smooth and clean cut as possible, therefore the cutting-edge must be on the outside of the tooth. This being so, it follows that the act of severing a fibre will be attended with compression, whose effect is to shorten it. Thus condensed it is forced up into the space between the teeth. If now this space is not so formed as to allow the condensed piece to drop freely away so soon as the tooth passes from the timber, then the saw will become choked, and its proper action will necessarily cease. In large saws this is provided for in the shape of the "gums" in which the teeth may be said to be set. What in America are called "gums" are frequently in England called "throats." Saws cannot work easily unless as much care is bestowed upon the "throats" or "gums" as is given to the teeth.

Any exhaustive attempt to deal with the considerations which present themselves to one who enters upon the question, what under all the varying conditions of the problems should be the form and set of a saw-tooth, would require more experimental knowledge and patient research than the subject seems to have received. There are more than 100 different forms of teeth. Sheffield and London do not agree upon the shape of the handle. The Eastern hemisphere and the Western do not agree whether sawing should be an act of tension or one of thrust.

The quantity of timber cut down in America must have led to investigations with respect to saws such as the requirements of this country were not likely to call forth. Hence we have very much to learn from the Americans on this point.

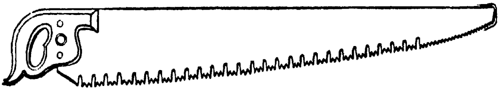


FIG. 55.

As it seems most judicious to investigate the principles by considering a large and heavy tool, perhaps it may be well to examine the largest handicraft saw. This (Fig. 55) is a "one-man saw" 4 ft. long, by Disston, Philadelphia. Long as the blade is, it is not too long. The travel is near, but still within the limit of a man's arm. To enter the wood, the teeth at the extreme end are used. These are strong, but of the form generally met with in the largest of our own cross-cut saws. The acting teeth are of an M shape, with a gullet or space between them. The angle at which the teeth are sharpened is very acute ; the consequence of this and of their form is that they cut smoothly as a sharp knife would do ; indeed, much as a surgeon's lancet would. Some teeth are formed on the principle of the surgeon's lancet, and these are called "fleam" teeth. The spaces between the M's in the "one-man saw" are "gums" for the reception and removal of the pieces cut out of the separated fibre. In the particular case before us, the **M** is $\frac{3}{4}$ in. broad and $\frac{3}{4}$ in. deep; the upright legs of the **M** are sharpened from within, the **V** of the **M** is sharpened on both sides. The legs are "set" to one side and the **V** to the other side. Thus arranged, the saw cuts equally in tension and in thrust, and the débris is brought out freely at each end. The **M** tooth for this double-cutting results from an observation on two carefully-toothed short cross-cut elementary saws, where it will be noticed that the form of tooth to cut both ways, resulting from the combination, is **M**. The set of this large "one-man saw" is worthy of notice. An inspection of the cutting points will show that each point is diverted from the plane of the saw blades not more than about $\frac{1}{32}$ in. When the object of "set" is considered, it will be allowed that so little is sufficient.

The annexed diagrams (Fig. 56) of teeth of certain cross-cut saws used in America may illustrate the present subject. A single tooth will in some instances be observed between the **M** teeth: this is a "clearance" tooth, and is generally shorter than the cutting tooth. Sometimes it is hooked, as may be seen in *c*; in such case it is shorter by $\frac{1}{32}$ in. than the cutting teeth, and acts the part of a plane iron by cutting out the pieces of fibre separated by the other or cutting teeth, which cutting teeth under these circumstances are lancet-like sharpened to very thin edges.

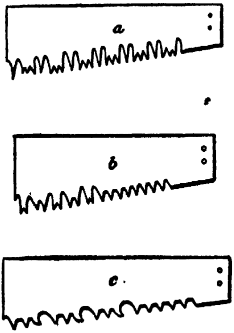


FIG. 56.

That the "set" of the teeth should be uniform in the length of the saw follows from a moment's reflection upon the object of this set. If one tooth projects beyond the line of the others, that tooth will clearly scratch the wood, and therefore leave a roughness on the plank. As more than its share of work is then allotted to it, the keenness of edge soon leaves it, and thus increases the labour of the sawyer. The American contrivance for securing a uniformity in the set of the teeth is the "side-file." The three set screws determine the elevation of the file above the face, and the travel of the short length of fine cut file reduces all excessive "sets" to a uniform "set" through the entire length of the saw.

The "crotch punch" is also an American contrivance for obtaining a clearance set out of a spreading of the thick steel of the saw by an ingeniously formed angular punch.

It is occasionally required to saw certain cuts to the same depth, as, for instance, in the making of tenons. The saw to which the term "tenon" is applied is more suited for cabinet than for carpenters' work. However, an ordinary saw may be provided with a gauge, which can be adjusted so as to secure a uniform depth in any number of cuts, and in this respect it is even superior to a tenon-saw, and may be suggestive to some whose labours might be facilitated by the adoption of such a contrivance.

The rip-saw, considered as a cutting tool, may be likened to a compound chisel, and the form of teeth which would operate with the least application of power would be the same as that of a mortising chisel; but knots and hard wood are conditions which call for rigid teeth, rendering the chisel form impracticable, except for sawing clear lumber, and with a high degree of skill in filing and setting. The limit of endurance of such steel as must be employed for saws will not admit of pointed teeth; these will break in cutting through knots and hard wood, and no form of saw-teeth which permits their points to crumble and break should be adopted. In actual practice, with the skilled filer there is a tendency to create pointed saw-teeth, and when there is a want of skill in the filer the tendency is the other way, and teeth unnecessarily blunt are common. "The action of a saw when ripping or cutting with the fibres of the wood is entirely different from that when cross-cutting or severing the fibres of the wood transversely; the shape of the teeth and the method of sharpening should therefore differ. In the case of a rip-saw the action of the saw is chiefly splitting, the teeth acting like a series of small wedges driven into and separating the longitudinal fibres of the wood; whilst with cross-cutting saws, the fibre of the wood has to be severed across the grain: it is comparatively unyielding, the teeth of the saw meet with much more resistance, and it is found necessary to make the teeth more upright and more acute or lancet-shaped than for cutting with the grain. The faces of the teeth should be sharpened to a keen edge, and for hard wood filed well back, so that in work they may have a direct cutting action, similar to a number of knives. Care should also be taken that the teeth are made of sufficient depth to afford a free clearance for the sawdust. This is an important point, too, with rip-saws. The teeth should also be equal in length; if not, the longest teeth get the most work, and the cutting power of the saw is much lessened. The length of the teeth should depend on the nature of the wood being sawn: for sawing sappy or fibrous woods, long, sharp teeth are necessary, arranged with ample throat space for sawdust clearance; care must be taken, however, that the teeth are not too long, or they will be found to spring and buckle in work. In sawing resinous woods, such as pitch pine, the teeth of the saw should have a considerably coarser set and space than for hard woods. It will also be found advisable—especially with circular saws—to lubricate the blades well, as the resinous matter is thus more easily got rid of. In sawing hard woods, either with reciprocating or circular saws, the feed should be not more than one-half as fast as for soft wood, the saw should contain more teeth, which should be made considerably shorter than those used for soft wood, roughly speaking, about ¼; it is impossible, however, to make a fixed rule, owing to the great variety of woods and their different hardnesses; the length of teeth which may be found to suit one wood well may in another case require to be increased or decreased. In cutting woods which are much given to hang and clog the saw-teeth, increment teeth may be used with advantage; these are arranged with fine teeth at the point of the saw, which gradually get coarser till the heel of the saw is reached; thus the fine teeth commence the cut and the coarser ones finish it, obviating in a great degree the splintering and tearing of the wood caused by coarse teeth striking the wood at the commencement of the cut. As regards the angles of the teeth best adapted for cutting soft or hard woods, no absolute rule can be laid down. The following may be modified according to circumstances. If a line be drawn through the points of the teeth, the angle formed by the face of the tooth with this line should be: For cutting soft woods, about 65°–70°; for cutting hard wood, about 80°–85°. The angle formed by the face and top of the tooth should be about 45°–50° for soft wood, and 65°–70° for hard. The angle of the tooth found best for cutting soft woods is much more acute than for hard. Terms used in describing the parts of a saw are :—"Space": the distance from tooth to tooth measured at the points. "Pitch" or "rate": the angle of the face of the tooth up which the shaving ascends, and not the interval between the teeth, as with the threads of a screw. "Gullet" or "throat": the depth of the tooth from the point to the root. "Gauge": the thickness of the saw, generally measured by the wire gauge. "Set": the amount of inclination given to the saw-teeth in either direction to effect a clearance of the sawdust. "Points": small teeth are reckoned by the number of teeth points to the inch. The chief facts to be borne in mind in selecting a saw with the teeth best suited to the work in hand are the nature and condition of the wood to be operated on. No fixed rule can, however, be laid down, and the user must be guided by circumstances. All saws should be ground thinner towards the back, as less set is thus necessary, the friction on the blade is reduced, and the clearance for sawdust is improved. Care should also be taken that they are perfectly true and uniform in toothing and temper. The angle of the point of a tooth can be found by subtracting its back angle from its front, and to do the best and cleanest work this angle should be uniform in all the teeth of the saw." (M. Powis Bale).

How to use a Cross-cut Saw single-handed. — In Fig. 57 is shown a means of using a cross-cut saw single-handed, to cut down a standing tree, or it may be used to cut a horizontal trunk, if the trunk is two or three feet off the ground. It will be seen that the sawyer takes one end of the saw, while a downward pull is exerted by an elastic pole secured as shown. This pole would be about 1 inch thick and cut from the nearest sapling or hedge. It will be found that the pole not only keeps the saw close to the work, but assists in hauling it as the sawyer pushes it from him. In felling a standing tree, the cut would only be made half through, then the pole would be shifted to the other side and a new cut started on the side opposite to the first one. By turning the illustration (Fig. 57) so that the saw is downwards, it will be seen that, by using a second pole, turned over in the opposite direction and secured to the other end of the saw, the sawyer can cut upwards single-handed.

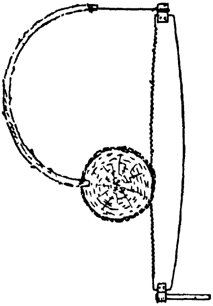


FIG. 57.

* * *

SEALING-WAX.

(*See also* SHELLAC.)

THE resin used for the best qualities of sealing-wax is shellac (bleached for light colours and best qualities, orange shellac for ordinary purposes) while ordinary resin (light or amber, or darker according to quality or colour) figures in recipes for the cheaper sealing-waxes.

Properties.—Sealing-wax should be glossy, smooth, not too brittle, unaffected by the hottest weather, melt without emitting any smoke or nasty smell, have sufficient tenacity not to drop about when melted, and should produce a seal of its own lustre and colour. The chief materials used in its composition are shellac and turpentine. The former is sometimes replaced wholly or partially by other resins, such as sandarac, benzoin, mastic, resin and pitch ; and the latter by balsams of Peru and tolu, and fragrant essential oils. In addition, there are some neutral substances employed to augment the bulk, as gypsum, chalk, magnesium carbonate, zinc white, etc., as well as the colouring matters.

Ingredients.—Only bleached shellac is admissible for the finest sealing-wax, though pale samples may do for some light-coloured grades ; the ordinary unbleached shellac is fit only for black and brown kinds of sealing-wax. Of the turpentines used, Venetian is the best ; but it may often be conveniently replaced by a mixture of resin and oil of turpentine, which possesses an advantage in the facility with which its fluidity can be increased or diminished. The turpentine will usually need to be filtered, which is best effected by heating it in a water-bath at the boiling temperature, 212° F. (100° C.), and passing it through linen. Other resins, balsams, and essential oils are used only in minor quantities, and should always be selected of good quality.

Colouring Matters. — The colouring matters employed should be good of their kind, though substances of inferior tinctorial power (and therefore cheaper) are of course resorted to for common kinds of wax.

The most general colour is red. For fine grades cinnabar is necessary ; but it so increases the weight of the wax that neutral bodies have to be used with it to counteract this tendency. Cheaper reds are minium, colcothar (Indian red), and bole. Madder lake is now replaced by coal-tar reds, of which the most fiery should be chosen.

Yellows embrace lead chromate (chrome yellow), which is generally used with some neutral white body (as chalk) ; Cassel or mineral yellow, from fused litharge ; and ochre, which is too dull and unpleasant-odoured to be available for any but cheap sorts of sealing-wax.

Greens are best obtained by compounding suitable proportions of blues and yellows, as the fine green pigments in the market are too costly for the purpose.

Blues include Berlin for the darker shades, and ultramarine and mountain blue for the lighter.

The best brown is burnt sienna, though crushed sienna and Cassel brown are used.

Blacks are exclusively represented by carbon in a very fine state of division, as lamp-black, ivory black, soot, etc. This last, which is very much cheaper than the others, may be made equally suitable by judicious treatment, which aims at destroying its brownish tint and unpleasant odour. The treatment consists in careful calcination, which may be conducted in a piece of stove-piping, about 18 in. long, and closed at each end by a tight-fitting cap, one being perforated with a hole somewhat less than a pencil, to allow of the escape of vapours. The pipe is filled to within 1½ or 2 in. of the top, when the covers are attached, and all joints and spaces carefully luted with clay, which may also conveniently form a protective coating to the whole pipe. The latter, when charged, is placed in an open furnace, with the perforated end upmost, and heated to redness. When the contents are thoroughly calcined the pipe is removed, allowed 24 hours to cool, and emptied. The soot will be found to have acquired a velvety black colour, and to have lost all odour. Frankfort or "vine" black is prepared by charring vine shoots in similar apparatus to that for calcining soot, washing the ash several times with water to remove alkaline salts, and once with water containing 25 per cent. of hydrochloric acid, taking care to use plenty of clean water after the acidulated water.

White pigments are used as much for making bulk as for imparting colour. Chalk is prepared by washing and drying the powder. Gypsum is used in the form of finest plaster-of-Paris, and the crystalline variety (selenite), powdered and washed, for translucent waxes. Magnesium carbonate is useful for mixing with heavy pigments, to reduce the weight, rather than as a colouring ingredient. Zinc white needs no preparation. Baryta or permanent white is valuable for enamel-like waxes, and may easily be prepared by dissolving barium chloride in rain water, and precipitating with sulphuric acid; the precipitate is washed several times with clean water and dried. Flake white is readily produced as follows: Fuming nitric acid is poured over some bismuth in a glass vessel till the metal is all dissolved. The solution is poured into another vessel containing about 100 times as much rain-water, and stirred up. A white powder (nitrate of bismuth) is at once precipitated; this is collected, washed, and dried, and is employed for the best enamel-like white sealing-wax.

Mica in fine powder is used to give a metallic lustre to cheap kinds of wax; bronze powder of all shades is employed for the same purpose in better grades.

Mixing.—It is essential that all the ingredients be dry, and to ensure this they are kept in paper bags on a shelf running round the walls of the stove-room at about 18 in. below the ceiling. The order of adding the ingredients is as follows: The resins and turpentine are first melted together; then the neutral bodies (chalk, etc.), if any, are stirred in; next the pigments are added; and the volatile balsams and oils are only introduced at the last moment before "forming." When only one pigment is used, it is simply warmed and stirred into the mass. When a shade is to be produced by a mixture of colours, no neutral bodies are added to the resins, but they are mixed with the colours in a china dish, warmed, and then added to the melted mass. Any required tint is obtained by mixing, and frequent testing.

It is important that the colouring matters be mixed to a paste, with spirit or oil of turpentine, before adding to the other ingredients. If this is not done, the wax may not be of a regular tint.

Melting.—The melting of the mass should be conducted at the lowest possible temperature, sufficing only to keep it in a fluid state. Quantities of 20 lb. to 25 lb. are treated at a time in a vessel large enough to permit quick stirring. Often the furnace used resembles an ordinary cook stove, the fire heating cast-iron plates; but these are objectionable from the inequality of the heating, and the risk of fire. Brannt describes an improved form of melter which serves also for the polishing. It consists of a small furnace about 3 ft. 3 in. high, fed preferably with small coke, having an upper and lower door for regulating the draught, but no grate, the ashes being withdrawn at the lower door. The stove is completely enveloped in a sheet-iron casing at a distance of about 2 in., and at the same height above the floor. The air between the stove and the casing becomes hot, and as it passes away it is replaced by a cold current entering at the 2-in. opening between the casing and the floor. Beside the casing of the stove, and connected with it, stands a table, surrounded by a sheet-iron screen, and bearing a sheet-iron tub filled with sand and provided with iron supports. The tub is covered with a plate of sheet-iron (for catching stray drops of wax), having 4 or 6 holes, which contain the melting pots. The hot air arising from the stove heats the sand tub and its contents, till the sealing-wax in the pots begins to melt. As soon as it melts the fire is slackened by closing the lower door, as the heat retained by the sand suffices for a long time to keep the mass in a fluid state. Enamelled cast-iron pots are best for melting in, keeping a separate pot for each mixture. Before using a pot for a new colour, it must be allowed to get quite cold, when the adhering wax can be easily cleaned off. The shellac is first put into the pot and melted, while being continually stirred with a flat paddle of hard wood; the turpentine is then intimately incorporated; next follow the neutral bodies and colours in a thin stream, with constant stirring, which is more necessary if the pigments are heavy. When the mass seems uniform, drops of it are examined by letting them fall on a cold, smooth, metallic plate, when the colour, hardness, and fracture can be tested. When satisfactory the heat is adjusted to maintain a fluid condition, aromatic substances are quickly stirred in, and "forming" is commenced.

Forming.—Sealing-wax is moulded into sticks in special "forms," consisting of one piece for rectangular or triangular sticks, but must be of two for oval or round. Forms in one piece are made of rectangular brass plate, carrying grooves $\frac{1}{16}$ in. wider at top than at bottom, for facilitating removal of the sticks. It is a common practice to put forms on a stove, or cool them off while moulding by placing them on metallic trays with cold water beneath, to cool the sticks rapidly; this releases the forms more quickly, but makes the sticks brittle, and it is better to let them cool gradually on a wooden table, while if the form becomes so warm as to much protract the setting of the wax, it may be dipped in cold water and carefully dried before using again. Engraved forms are difficult to turn out, but this may be partly remedied by slightly rubbing the engraved parts with oil of turpentine. Surface ornamentation, as gilding or silvering, is effected by placing the substance in the form. As brass forms are expensive, they are sometimes replaced by home-made ones of type-metal. To produce them, a stick of fine wax is coated with a thin film of olive oil, and a cast of it is taken in plaster-of-Paris; when this is thoroughly dry it is put into a small wooden box, and melted type-metal is poured round to make a form. The forming of the wax is conducted as follows. The molten wax is ladled from the pot into a casting-spoon, previously heated. By this it is poured in a uniform stream into the forms. These should be slightly warmed before the first moulding takes place.

Polishing.—Polishing, dressing, or enamelling is usually applied to all grades, though the finer qualities have a lustrous surface on coming out of the form. When the improved furnace before mentioned is not in use, a special polishing stove is necessary. This consists of an iron slab covering a vault, heated by a fire beneath. The sticks are taken in the hand and held in the heat of the polishing stove till the surface begins to melt and the sticks bend. When thus softened they receive an imprint of the maker's name or some other device, composed of letters held in a little brass hand-frame. The sticks are patted between small wooden boards at the same time, to retain their shape. For gilding, silvering, or bronzing, the part to be ornamented is touched with a brush dipped in strong spirits of wine, and the gold or silver leaf or bronze powder is applied, and adheres tenaciously.

Miscellaneous Receipts.—The following recipes for the compounding of sealing-waxes will be found to embrace all that are of general utility.

Black.—(1) 5 parts shellac, 9 turpentine, 6½ pine resin, 4 chalk, 1¼ soot.

(2) 8 parts shellac, 6 turpentine, 6 resin, 1½ chalk, 1 gypsum, 3½ vine-black.

(3) 48 parts shellac, 52 turpentine, 46 pine resin, 28 chalk, 8 soot, 8 bone-black, 8 asphaltum.

(4) 2 oz. Venice turpentine, 4½ oz. shellac, ¼ oz. colophony, 1¼ oz. best lamp black. Melt together the first three ingredients, then mix the black to a paste with oil of turpentine, and add to the other ingredients.

(5) ½ lb. yellow resin, 2½ oz. button lac, 2¾ oz. Venice turpentine, ½ oz. lamp-black or ivory-black. Melt the lac, add the resin, then the turpentine (slowly and carefully). Make a paste of the black with turpentine and add this last.

(6) As medium fine red (5) using lamp black instead of vermilion. Rub the colour well in.

Blue.—(1) 7 parts shellac, 6 turpentine, 3½ pine resin, 1 magnesia, 2 chalk, 2 to 2½ blue colouring matter. (2) Light-blue sealing-wax is produced by mixing Berlin-blue with oxide of zinc or nitrate of bismuth, and has a beautiful enamel-like appearance. As blue colours are very sensitive, bleached shellac should always be used, and care must be exercised in the choice of the resin, that which is opaque and brown-coloured being rejected. (3) Substitute fine Prussian-blue for the vermilion (same quantity), in medium fine red (5).

Bottle.—The most ordinary sorts of sealing-wax are used for bottles, and of course can only be coloured with the cheapest kinds of tinctorial matter. Many makers prepare bottle-wax of a mixture of common pine-resin, turpentine, chalk, and the respective colouring matter only. Such are very cheap, but they do not answer the purpose so well as they should. The corks are covered with a layer of sealing-wax by dipping the necks of the bottles into the melted mass. This congeals very quickly on the cold glass, and consequently at once becomes brittle, and frequently breaks when gently touched. On trying to make the wax less brittle by increasing the turpentine, it oftens happens that it remains sticky even in cold weather. To avoid these evils, add a certain quantity of shellac, 10 to 15 per cent., to the composition. This will increase the cost of the article somewhat, but its quality will be so much improved that it will not become sticky even in a hot climate.

(1) Resin, 6 oz.; shellac, 2 oz.; Venice turpentine, 2 oz.; melt and add lamp-black, 9 oz. Pour into moulds. (2) Common resin, pitch, and ivory-black, equal parts. (3) Another: common resin, 20 lb.; tallow, 5 lb.; lamp-black, 4 lb.; mix with heat. (4) Red: common resin, 20 lb.; tallow, 5 lb.; red lead, 6 lb.; mixed with heat. (5) 4 oz. shellac, 1 oz. Venice turpentine, and 3 oz. vermilion. Melt the lac in a copper pan, suspended over a clear charcoal fire, then pour the turpentine slowly into it, and soon afterwards add the vermilion, stirring the mixture briskly all the time with a rod in either hand.

Bronze.—Proceed as for gold, but instead of 3½ oz. of gold bronze powder, use 2 oz. of this and 1½ oz. emerald green.

Brown.—7 parts shellac, 6 turpentine, 4 pine resin, 2 gypsum, 2 chalk, 2 umber. The shellac for preparing chocolate-brown sealing-wax must not be too dark. The product of the above recipe is dark-brown, and unbleached shellac and dark resin may be used for preparing it.

Deed.—Large seals for deeds and public documents are not imprinted in ordinary sealing-wax, but a mass which is half soft, even at normal temperatures, is used for the purpose, and to protect the seal from injury it is enclosed in a special case fastened to the document by cords or ribbons.

(1) 6 parts light-coloured resin, 3¼ turpentine, 3 clarified tallow, 4 whiting, 3 to 4 minium. (2) 5 parts white wax,

1½ turpentine, 1 cinnabar, ½ glycerine. The ingredients are melted together and stirred while cooling off until they congeal. (3) 3 parts colophony, 1½ tallow, 3 turpentine, 4 chalk, 4 minium. This mixture is of firm consistency at ordinary temperatures, but if a piece of it is held in the hand for some time it becomes so soft that impressions can be taken with it, and it adheres also with some tenacity to paper, wood, and glass.

Gold.—8 oz. amber resin, 5 oz. Venice turpentine, 12 oz. orange shellac, 1 oz. light magnesia, 3½ oz. gold bronze powder.

Green.—(1) 7 parts shellac, 8 turpentine, 4 pine resin, 1½ magnesia, 2½ Berlin-blue, 2½ chrome yellow. (2) 5 parts shellac, 4 turpentine, 8 pine resin, 1½ gypsum, 2 chalk, 3 mountain blue, and 3 ochre. Green ultramarine may be used to advantage for the finer qualities, instead of a mixture of colours. (3) Proceed as for medium fine red (4) but use 4 oz. of emerald green instead of the 3 oz. of vermilion. (4) 1 lb. yellow resin, 5½ oz. button lac, 5½ oz. Venice turpentine, ½ oz. King's yellow, ½ oz. prussian-blue, 1½ dr. carbonate magnesia moistened with oil of turpentine.

Letter, without a light.—3 parts colophony, 3 resin, 3 suet, 4 Venice turpentine, 4 pulverised carbonate of lime, 4 pulverised minium. Melt the three first ingredients together, then add the others in succession, stirring constantly till cold. ('Moniteur Quesneville.')

Parcel.—(1) 3½ parts shellac, 6½ resin, 5 turpentine, ½ oil of turpentine, 2½ chalk, 1 gypsum, 2½ cinnabar.

(2) 2 parts shellac, 8 resin, 5 turpentine, ½ oil of turpentine, 3 chalk, 5½ gypsum, 6 minium.

(3) 1½ parts shellac, 8½ resin, 6 turpentine, ½ oil of turpentine, 2 chalk, 1 brickdust, 5 colcothar.

(4) 20 parts colophony, 10 pine resin, 5 turpentine, 7½ chalk, ⅓ oil of turpentine.

(5) For brown, 10 parts umber or bole are added to (4).

Red.—The beauty and price of red sealing-wax are determined by the quantities of shellac and cinnabar contained in it; only the finest qualities have cinnabar exclusively as a colouring principle. The inferior kinds contain very little shellac but much common resin, and no cinnabar at all, minium, colcothar, bole, or other cheap pigments being substituted. But too much resin must not be added, or the wax will become too thin, drop too easily, and smoke very much when lighted. It is asserted that chalk should not be used, because the acids of the shellac expel carbonic acid from it, and form a combination with the lime; but this happens only when the shellac is heated more than necessary, as no carbonic acid is set free if the shellac is only heated to the melting-point.

Very fine reds are—(1) 12 parts shellac, 8 turpentine, 9 cinnabar, 2 oil of turpentine, 3 magnesia.

(2) 11 parts shellac, 6 turpentine, 1 oil of turpentine, 1 chalk, 2 magnesia, 8 cinnabar.

(3) 10 parts shellac, 1 turpentine, ½ oil of turpentine, 1½ chalk, 1½ gypsum, ⅕ magnesia, 6½ cinnabar.

(4) 50 parts shellac, 12½ Venice turpentine, 37½ Chinese vermilion.

(5) ½ lb. very pale shellac melted cautiously over a clear fire in a polished copper pan. When melted add cautiously 2 oz. Venice turpentine and mix. Lastly add 6 oz. vermilion.

Medium fine reds.—(1) 1 part shellac, 8 turpentine, ½ oil of turpentine, 3 chalk, 1 magnesia, 6 cinnabar.

(2) 6 parts shellac, 4 resin, ½ oil of turpentine, 7 turpentine, 1½ chalk, 1½ gypsum, 4½ cinnabar.

(3) 4 parts shellac, 6 resin, 6 turpentine, ½ oil of turpentine, 2 chalk, 1 gypsum, 4 cinnabar.

(4) 8 oz. amber resin, 5 oz. Venice turpentine, 12 oz. orange shellac, 3 oz. vermilion, 1 oz. carbonate magnesia, 80 gr. benzoic acid. Melt the resin, add turpentine carefully, then the shellac, using gentle heat until liquid. Mix the powders and add to the liquid,

stirring well. As soon as well mixed pour into moulds.

(5) Shellac, 8 oz.; Venice turpentine, 4 oz.; vermilion, 2½ oz.; alcohol, 2 oz.; camphor gum, ½ oz. Dissolve the camphor in the alcohol, then the shellac, adding the turpentine, and finally the vermilion, being very careful that no blaze shall come in contact with its fumes; for if it does, it will fire very quickly.

Fine red.—55 parts shellac, 74 turpentine, 30 chalk or magnesia, 20 gypsum or zinc white, 13 cinnabar.

Ordinary red.—(1) 52 shellac, 60 turpentine, 44 pine resin, 18 chalk, 18 cinnabar. (2) 50 resin, 37½ red-lead, 12½ turpentine.

Yellow.—Only lead colours can be used for yellow sealing-wax, and of these chrome-yellow produces the most beautiful colour. But if sealing-wax compounded with chrome yellow is very strongly heated in lighting it, the mass becomes discoloured, in consequence of a decomposition of the lead colours. Therefore yellow sealing-wax must be very fusible to avoid this evil. Every kind of sealing-wax becomes more fusible by adding a larger quantity of turpentine, but it also becomes softer. Fine yellow: 76 parts shellac, 85 turpentine, 45 pine resin, 15 gypsum, 15 chalk, 45 ochre. The shellac used for fine qualities of yellow sealing-wax must be bleached, or it will be impossible to produce a pure tone of colour. All gradations of yellow, from orange to red, can be produced by adding cinnabar or chrome-red to fine qualities, and minium to inferior qualities of sealing-wax.—('Brannt.')

Translucent.—Translucent sealing-wax belongs to the very best qualities, as only highly refined materials can be used for it. Bleached shellac alone is not sufficient; sealing-wax only becomes translucent by adding a corresponding quantity of mastic, and by using very fine, light-coloured, and very viscid turpentine. Following are three recipes for preparing translucent sealing-wax, which may be coloured by mixing suitable pigments with it. A beautiful variety ("aventurin"), which can be prepared at comparatively low cost, is obtained by stirring finely powdered mica into the melted ground mass. Gold and silver waxes are obtained by mixing finely powdered leaf-metal with the melted ground mass. Ground masses for translucent wax are:—(1) 1½ parts bleached shellac, 1½ viscid turpentine, 3 mastic, 1 chalk.

(2) 3 parts bleached shellac, 4 viscid turpentine, 5 mastic, 3 sulphate of baryta (or 3 nitrate of bismuth).

(3) 3 parts bleached shellac, 4 viscid turpentine, 5 mastic, 3 sulphate of baryta (or 3 nitrate of bismuth). No. (3) is especially adapted for preparing "enamelled" sealing-wax, which actually possesses the half transparent appearance of enamel, and is particularly beautiful when a tender rose-colour is given to it by using fiery madder-lake.

Sealing-wax with Wick.—Sticks of sealing-wax can be had with a wick up the centre. The wick is made up of 8 to 12 cotton threads, saturated with wax or stearin, the threads being held stretched while the wax is cooling on them. The threads are held taut in the mould while the molten sealing-wax is poured around them.

* * *

SEWAGE DISPOSAL FROM ISOLATED HOUSES.

THIS is probably one of the most important subjects a sanitarian has to consider when dealing with a house in a country district, for whether the building be large or small all sewage matter must be disposed of in a proper and efficient manner. It is an undertaking which by itself usually requires all a man's skill if the work is to be done effectually; and when it is complicated by the water supply being drawn from adjacent wells or lakes, much ingenuity and experience are required.

Cesspool System.—With cesspools the conditions have to be decidedly favourable as to fall or nature of ground, or distance from water supply, otherwise there is risk of dangerous features. If all cesspools were made watertight the risks would be minimised, but this arrangement, although sometimes carried out, involves great expense in attention (emptying, etc.), as all fluids as well as solids are retained. It also leads to an economy of water being practised, which is not always good, for in the few houses which have watertight cesspools it becomes quite natural to avoid discharging fluids into the drainage system to the utmost possible extent, remembering that every gallon used has to be pumped out. The writer's practice in the past when arranging the cesspools of country residences was to have a series of three pits at as low a position as possible, these being simply lengths of 30-in. drain piping fixed on end. The first one was cemented at bottom, this being the catchpit for solid matters, the other two had open bottoms for the fluids to soak away. This was of course, dependent on the subsoil being porous, and the drinking water supply being at a considerable distance. Communication between the three was made by a 6-in. pipe near the top. This arrangement, however, though cleaner and of a more sanitary nature than brick-built cesspools and soakaways, has no effect in purifying the sewage, and the object of these pages is to describe the best known means of rendering sewage harmless.

Sewage, from a chemist's standpoint, is almost wholly water, the true solids being little more than say three parts in a thousand, and of these three parts no more than half is organic matter, the remainder inorganic. It is the organic matter which has to be dealt with, as this decomposes and putrefies, and is liable to bring into existence gases and organisms that are dangerous to life. Sewage literally swarms with bacteria, but they are not dangerous if properly disposed of, excepting, of course, microbes of infectious diseases which are brought down with the excreta of infected persons. The ordinary sewage bacteria rapidly convert the organic material into chemical compounds of a less objectionable nature, provided there is a sufficiency of oxygen, and some purifying processes rely for their efficacy on this.

Sewage Farming.—Two very good and rather simple means of disposing of sewage from large residences are by Sewage Farming, or by Intermittent Filtration. The former is effected by irrigation, the ground being laid out in slopes more or less steep according to its ability to absorb moisture, in much the same way as lands are irrigated with water; and crops are grown on the land so treated. Little opposition can be raised to this mode of treating the sewage, as such works, properly managed, are inoffensive, whether the house be near to or far from the ground so treated. Crops raised on such ground are as safe and good to eat as those grown in the ordinary way, and flesh or milk from animals raised on this food is as pure and satisfactory as any.

The land most suited for sewage farming is that having a somewhat light, open soil which is porous and does not resist the passage of liquids into and through it. The crops grown would be, of course, those that benefit the most by a large share of moisture. It is best not to attempt it with heavy soil, although it is possible with this by employing a much larger area of land for a given quantity of sewage, and laying it out more flatly, that the sewage may not pass over it too rapidly. With land that is fairly suitable for the purpose one acre is considered sufficient for the sewage from a house or houses containing a total of sixty to eighty or even a hundred persons; this is not the maximum that this area of earth is capable of dealing with, but it is as much as most crops can stand. A greater quantity of sewage would be fatal to them, causing their destruction. This method of disposing of sewage from country residences is decidedly hygienic in its character. The ground so treated would, of course, be at a lower level than the house, to admit of the sewage flowing direct there by gravitation, and it is then directed into channels which, provided with sluice gates, make it a fairly simple task to treat the ground in sections in regular rotation. Distributed over the land in this way there is every opportunity for nature to do the purifying work, of which it is so capable, in a thorough manner, and it is generally conceded that the sewage, applied sparingly in this way, is rendered innocuous. Added to these facts it must be remembered that water for irrigation purposes is almost unattainable in some districts during the summer-time, when it is needed; in fact every drop of water is valuable in some localities, and the use of sewage for watering and fertilising is a distinct gain; it may be more widely practised than it is.

Intermittent Filtration.—Intermittent filtration differs from irrigation, although it is the application of sewage to land for the purpose of effecting its purification and disposal. It also differs from what many may suppose filtration to mean, for it is not merely straining the solids from the fluids, but is a means of exposing sewage to the beneficent action of the air and nitrifying agents before the material passes deep into the ground. This system and sewage irrigation are the only processes by which the organic matter can be removed from sewage and transformed without the aid of chemicals. Even irrigated areas, unless the land is good, may require a filter bed to assist in very bad winter weather. The system now under discussion is fairly simple and does not need skilled labour. The beds consist of suitable sized sand, placed above the level of the subsoil water, in beds about 4 to 5 ft. thick. The drainage system delivers the sewage on to the bed or beds at several points, while under the bed there requires to be a simple system of subsoil pipes to carry away the clear liquid that comes through.

An intermittent action is necessary, as the success of the system is in giving the beds a rest that the purifying action can be completed with one layer or film of sewage before another is superimposed. It is therefore arranged that there be two or more beds, and while one section is receiving sewage the other is shut off to deal with what it has received and recover itself. It is of some importance that the grains of sand be of a fairly regular size, and, unlike a filter, there is a disadvantage in making the bed of sand or material of different sizes. It should not be fine at top and large at bottom, nor the reverse. The sand should be sharp and not fine; what is generally known as coarse sand is the best. If the sand is too fine the action is slow and it gets clogged, while particles which are too large allow the sewage to pass more rapidly than it can be properly acted on.

The success of the process depends on air existing in the interstices between the grains of sand, for without air the micro-organisms which do the purifying work cannot exist. When sewage is admitted on to the sand air is imprisoned below it as well as existing on top, and provided more material is not added too soon the required action will occur successfully, and the material will drain through the bed and pass away. The process, explaining it another way, is the intimate contact of the sewage in small volume with air that is for the time intermingled with it, and, given sufficient time, the nitrifying work of the bacteria effects the desired change efficiently. As one volume of sewage is disposed of it goes down; new air then occupies the interstices in readiness for new work. The beds will do good work for some time, but if there appears to be any clogging, then, if the sand is of regular size, it will be found quite superficial, and the upper surface need only be raked over. If desirable a thin layer of the sand, with the coating of sludge, can be scraped right off, and this may be repeated from time to time until the thickness of the bed is reduced, say 12 in., after which some new sand must be added to make it up to its former thickness. It is very desirable, of course, that the sewage be brought to the beds in a way that will not disturb the surfaces more than possible, and it should be distributed as evenly as can be done. The area required for the filter beds is not nearly so large as for sewage farming, as one acre is considered by most authorities to be sufficient for one thousand persons, but no cropping can be done with beds which receive such a proportion of sewage as this.

The Septic Tank System.—(*a*) This important method of treating sewage relies for efficacy on the growth of a micro-organism which, it is claimed, not only breaks up and liquefies solids, but also acts with destructive effect on disease germs. Of course, any system of sewage purification which disposes of sludge is worth consideration, owing to the reduction in attendance and working expenses. Sludge, although having manurial value, has to be collected and removed from the sewage plant; and the best means, that of pressing into solid cakes, is scarcely possible with the arrangements of a private residence, however large, and the septic tank principle is relied on to obviate this trouble, as no sludge is said to be made.

Mr. Scott Moncrieff made investigations as to the purifying action of micro-organisms upon sewage, on a practical scale, in 1891, with the conclusion that the principle was found reliable, and it was also discovered that the organisms were capable of cultivation, for the tanks were found to improve and become more active in their work after a time. This latter fact was proved by recharging the tanks with new material, when their efficacy became reduced, but by putting back the old material their best work was immediately experienced again. Thus it will be seen that instead of constant attention in renovating the purifying materials or agents, a certain length of time shows a growing improvement in their working capabilities.

A peculiar feature is that the liquefying organisms act best in the absence of light and air, and with no more than a sluggish movement in the tank—in fact, light and air are fatal to them. Particulars kindly furnished by the surveyor to the patentees describe the process as follows: "The method adopted is to pass the sewage into closed tanks specially fitted to hasten the natural decomposition of the animal and vegetable solids. This work is performed by the micro-organisms or bacteria with which sewage always teems, as they feed or act on the organic matter and convert it into inoffensive compounds, which are dissolved and carried off by the flow as fast as they are formed. This, however, is not the only service performed by the bacteria in the tanks, for it is now recognised that the disappearance of the pathogenic organisms or 'disease germs' from sewage is due to these same bacteria, which attack and speedily destroy them. The work of the tank is thus twofold, consisting first in the liquefaction of the sewage solids, and, secondly, in the destruction of the germs of disease. No chemicals or other ingredients of any kind whatever are added to the sewage, and no sludge is produced. The effluent from the tanks passes out in a continuous stream, and is treated by filtration.

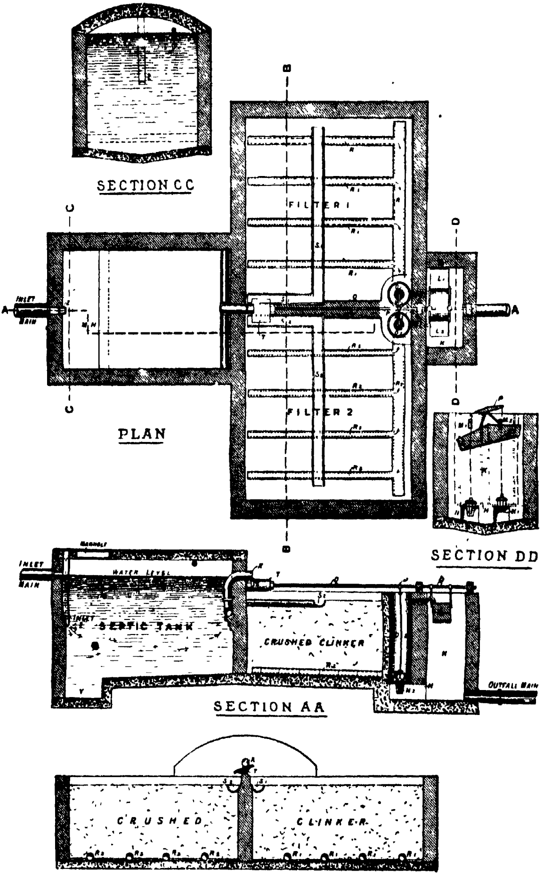
"The filters under this system are similar to those adopted by Mr. Dibdin, Chemist to the London County Council, being constructed of coke breeze or crushed furnace clinker. The method of working also is that recommended by Mr. Dibdin, the filters being first filled and allowed to remain full for a short time, then emptied and allowed to stand empty for a few hours in order to drain and aerate the filtering material. In this way the filters are kept well supplied with the oxygen necessary for purifying the effluent poured on to them. The filtering area is, of course, divided into several parts, each of which in turn receives the effluent in order that the process may go on continuously.

"In Mr. Cameron's system the filling and emptying of the filters is effected automatically. In an ordinary installation where four filters are used, one filter will be filled at a time; as soon as it is full the automatic apparatus will divert the flow of effluent to a second filter, the discharge valve of which it will at the same time shut down. It will also open the discharge valve of a third filter which has been previously filled, and shut the valve by which that filter was supplied with effluent. Thus there is always one filter resting full, another filling, a third discharging, and a fourth aerating. A fifth, or spare filter, is provided which can be set at work in place of any of the other four. The apparatus is simple and reliable, one set having effected over 1500 discharges. No labour or attendance is necessary beyond an occasional inspection, though at intervals of a month or more it may be desirable to rake over the surface of the filters.

"The works laid down at Exeter in the summer of 1896 were to deal with the flow of one of the outfall sewers. They were set to work in August of that year, since when the average flow of sewage has been somewhat over 50,000 gal. per day. These works have demonstrated the capability of the system for dealing with sewage under all the changing conditions which are met with in practice. This system can be easily adopted for comparatively small requirements."

The illustration, Fig. 58, is from a drawing furnished by the surveyor to the patentees, this representing an installation suited for a country mansion. The explanation of the lettering on plan is as follows: Z, inlet to septic tank; Y, sump for grit; X, outlet to septic tank; T, diverter; S_1, S_2, channel pipe distributors over filters; R_1, R_2, collecting pipes at bottom of filters; Q, shaft; P, rocker; O_1, O_2, wells for discharging valves; N_1, N_2, discharging valves; M_1, M_2, overflows from wells to actuating buckets; L_1, L_2, actuating buckets; K, well for actuating buckets; H, cast-iron plate with seats for valves N. (Davis and Dye's 'Plumbing and Sanitation.')

(*a*) The septic treatment of sewage may be considered a biological rather than a chemical process, as its success is dependent upon presenting conditions which favour the rapid growth of certain bacteria. In the complete reduction of sewage by the septic method, bringing it to a harmless state, in the form of nitrates which plant life can take up, two forms of bacteria are employed—anærobic and ærobic. Air and light retard the multiplication of the first of these. The second requires oxygen and multiplies rapidly in the open air. The tank or receiver proper, is a sort of catch basin, made in form to favour the requirements for the propagation of the anærobic bacteria, which reduce the sewage to simple compounds. The tank, it appears, should hold the output of about one day's use of the fixtures discharging into it. Light and air should be excluded. Warmth to a degree is essential, such heat as is



SECTION CC

PLAN

SECTION DD

SECTION AA

SECTION BB.

Fig. 58

common to a pit in the earth closed at the top, with no unnecessary exposure, together with the heat of waste water, and that generated by the action taking place in the sewage itself being sufficient to favour the process in winter weather of quite severe climates. 54° F. has been stated to be the minimum temperature permissible in this tank, for little or no septic action can take place at lower temperatures. The waste water of baths and lavatories are not turned into the septic tank alone for the heat they bring, but to secure dilution of the excrement and matter from other sources, which not infrequently carry too little water to favour the best interests of the process. Both the inlet and the outlet of the tank should be arranged to be below the surface of the contents when the tank is full, so that the scum which generally forms on the surface will not be disturbed by entry or exit of matter. This scum, resembling wet ashes, helps to retain the heat and excludes light and air from the mass—all favouring the accomplishment of the purpose. The scum may be from a few inches to fifteen or twenty in thickness, according to conditions and nature of the plant.

The contents leaving this initial receptacle having, in it, been brought down from its complex nature to one of simple chemical compounds, principally nitrites, the completion of the reduction process and the change from nitrites to nitrates is brought about by exposure of the matter to light and air, giving the ærobic micro-organisms a chance to get in their work. This would be accomplished by simply discharging directly into a stream, but a more rapid action is obtained by interposing an open shallow bed of broken stone or slag for the liquid to first flow through, so as to break up and bring into contact with the air as large an amount of surface as possible before piping to stream or otherwise. In this way a more complete reduction is certain before the matter reaches any final source of disposal.

The bacteria necessary to the process are always present in abundance in fresh sewage, and no preliminaries are necessary to operation as described. The resulting product is described as a harmless, colourless, and odourless liquid. In this process, admission of air to the tank or lack of sufficient heat or dilution may result in a putrescent state of the matter, as is found in a common cesspool. As previously indicated, the septic process is not yet widely used, except for town sewage, where it is rapidly gaining in favour. Here elaborate methods are adopted to favour the ærobic or oxidising end of the operation, mostly through filters of special design, all aiming to secure absolute stability and harmlessness of the final discharge from the sewage disposal plant. Better acquaintance will doubtless develop much data bearing on the latitude of conditions under which it will successfully operate. From 8 to 17 days are necessary to set up septic action according to season and conditions.

(*b*) In the following three illustrations, Figs. 59, 60, and 61, are some details of a septic tank plant installed at an American fort. Fig. 59 gives a plan of the complete plant, which, as will be seen, consists in the disposal of sewage from a toilet house containing three anti-freezing water closets.

The lack of heat in the house, as well as other conditions, makes the use of this type of water closet a necessity in the present instance, and it also necessitates the location of the water closet tank outside of the bowl, and at a considerable distance below it. Under ordinary circumstances this course would be inadvisable. However, it is with the disposal of the sewage that we shall speak principally, as this appears to us the most interesting part of the plant.

Fig. 60 gives an elevation of the toilet house, and Fig. 61 a similar view of the tanks into which the sewage is delivered.

The tanks in this case comprise two

separate compartments. In large work very often three and even more compartments are made use of.

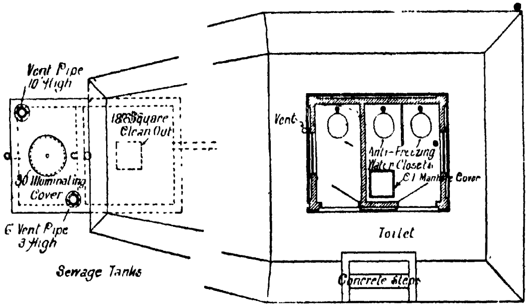


FIG. 59.

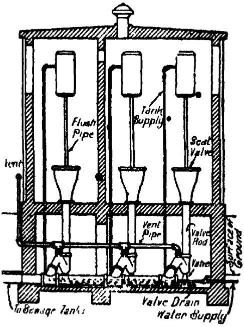


FIG. 60.

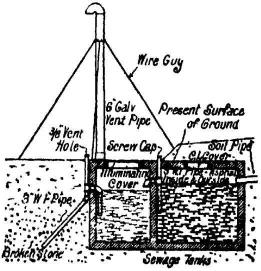


FIG. 61.

The chief purpose of the tank into which the sewage is first delivered is to allow the liquids to settle, thus allowing the greater part of the solid parts of the sewage to remain in the first tank, the liquids overflowing into the second tank, from which they overflow a second time into a mass of broken stone, gravel, etc. In the latter the liquids are purified by the action of natural filtration. It will be seen, then, that the larger the number of compartments or tanks through which the sewage passes, the more perfect will be the action of this apparatus, for the water will be delivered into the filtering material in a correspondingly clearer state. It will also be seen that a plant of this nature is capable of doing very complete and entirely satisfactory work, providing the arrangement of the tanks is right, and the filtering material is of sufficient amount. Of course if solid matter to any extent is allowed to pass off into the filtering material the latter soon becomes clogged with foul matter, in which condition it is incapable of performing its work, and the entire plant becomes a filthy nuisance.

We have stated that the first tank is used as a settling tank. As a matter of fact, in each tank another action also takes place, upon which the success of such sewage tanks is almost entirely dependent. After the tanks have been in operation a short time, it will be found on removal of the cover that a thick, heavy coating has formed on the surface, this mass being made up very largely of animal and vegetable matter. These two classes of matter are very susceptible to the action of minute animal life which exist in all tanks of this nature, and which multiply at a very rapid rate.

These microscopic animals attach themselves to the sides of the tanks, and to the under side of the surface coating of vegetable and animal matter. They attack the matter with which they are in contact, and rapidly disintegrate it. The particularly valuable feature of this action is that vegetable and animal matter of every description is transformed by these minute animals into liquids. Their action is so complete that leather, bones, etc., entering a septic tank of this nature are readily disintegrated, the action, however, being of somewhat longer duration than in the case of softer substances.

It will be clearly seen, then, that in order that the action of these animals, and their breeding, may not be disturbed to any greater extent than possible, it is advisable to use every precaution against breaking up or disturbing the crust that forms at the surface.

This is the principal reason for running the overflows shown in Fig. 61 to a considerable distance below the surface of the contents of the tanks into which the sewage is delivered.

In the case of the overflow between the two tanks, we believe it would be full as well to have the delivery end below the surface. We should advise the entrance of the soil pipe from the toilet house in the same way, that is, by taking the pipe down below the surface.

Another feature that is of value is the pitching of the bottom of each compartment towards one end, so that all matter which is not liquefied and carried off, may find its way to the low point, from which point it may be cleaned out more readily, or drained off. The running of the vent pipe as shown in Fig. 61 is a good feature, as also the placing of cleanout caps on the overflows, for use in the event of stoppage. It is said that this plant, which is in operation at Fort Hancock, N.J., is giving entire satisfaction. We see no reason why this should not be true, as the plant is in general well drained, and we know that when installed in a proper manner the septic tank is an invaluable aid in the disposal of sewage at points where there is no system of public sewers. ('Plumbers' Trade Journal.')

Septic Tank Principle.—(*b*) We are indebted to the Royal Society of Arts for the following illustrations of a typical septic tank installation which were given in a lecture by Dr. Samuel Rideal:—

The natural process consists in :—

(1) Liquefaction of the insoluble matter, and modification of the dissolved matter, in a closed space, therefore mainly by anærobic bacteria.

(2) Oxidation afterwards by the help of ærobic bacteria during passage through a porous medium like land.

The processes should be properly and systematically conducted in natural sequence. Any mixing or confusing in the order, any artificial interference, or attempt to work distinct reactions simultaneously in the same receptacle, will lead to uncertainty and irregularity in the results.

In 1895 Mr. Cameron, City Surveyor of Exeter, introduced his "septic tank" process for the treatment of a portion of the sewage of the city, comprising about 2,000 persons, on the combined system, yielding about 50,000 gallons of sewage. After passing through a grit chamber where gravel brought down by the rains was detained, the liquid containing all the organic solid matter emerged into a closed tank, through which it slowly passed. The details are well known and are indicated in the illustrations. (Fig. 62.) The present tank has a capacity of 53,800 gallons, therefore holds approximately a day's supply, hence the time of remaining in the tank is about twenty-four hours. In this way the sewage becomes mixed and averaged, and the bacteria have a chance of working during the passing through the 65 feet length of flow, which the sewage traverses at the rate of a little more than 2 feet per hour. No obstruction is present, and the entire space is available, differing from what we have seen of tanks partially filled with stones or coke. In the latter the dimensions must either be larger in proportion, or the sewage must pass at a greater rate, the bacteria also are not so freely distributed through the liquid. From the inspection chamber it is seen that a leathery scum from 2 to 6 inches thick, according to the position, collects on the surface and renders the whole anærobic. Below this is a zone of fermentation, in which the sewage is mainly clear, but bubbles of gas keep the liquid in a state of quiet admixture. At the bottom of the tank there is a layer of the dark peaty matter, previously referred to, which is so small in amount that during a period of a year's working, it does not require to be removed. The organic matter in it is gradually broken up by the bacteria, the inorganic matter is raised by the gases and gradually carried off in the flow, so that its quantity does not sensibly increase.

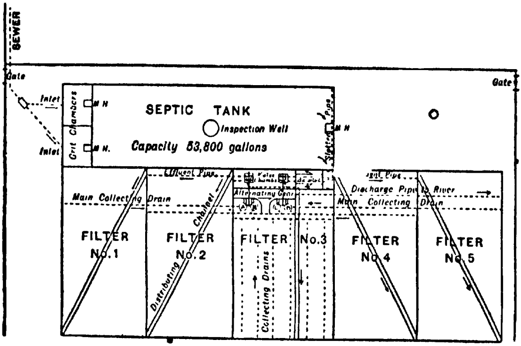


FIG. 62.—Sketch Plan of the Septic Tank Plant at Belle Isle for Dealing with Sewage of St. Leonards, Exeter.

Area of each filter, 80 sq. yds.; and depth 5 ft = volume 22,500 gal.
Effluent introduced at start = 0·6 of above volume ∴ 0·4 of original volume = coke.
Effluent introduced in ordinary working from 8000-9000 gals per filter.
A, B, C, D are collecting wells, receiving filtered water from the four filters in use.
By means of the alternating gear, each filter in rotation is filled, discharged, and aerated automatically.

Diagram of Overflow Pipes.

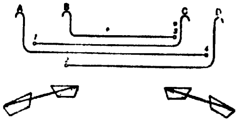


FIG 63

Diagram showing successive states of Filters corresponding to successive positions of alternating gear :—

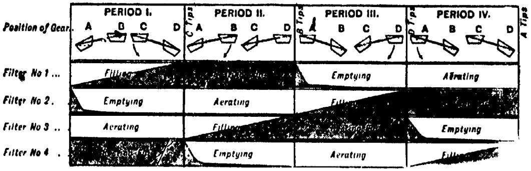


FIG. 64.—Cycle for 4 Filters, Nos. 1, 2, 3 and 4, Discharging into 4 Collecting Wells, A, B, C and D.

At starting, let filter No. 4 be already full and resting, and No. 1 filling,—Period I.
When No. 1 fills, it overflows into tipper C, discharging No. 4, putting down outlet valve of No. 3, and admitting effluent to No. 3.—Introducing Period II.
When No. 3 fills, it overflows into tipper B, discharging No. 1, putting down outlet valve of No. 2, and admitting effluent to No. 2.—Introducing Period III.
When No. 2 fills, it overflows into tipper D, discharging No. 3, putting down outlet valve of No 4, and admitting effluent to No. 4.—Introducing Period IV.
When No. 4 fills it overflows into tipper A, discharging No 2, putting down outlet valve of No. 1, and admitting effluent to No. 1.—And so on.

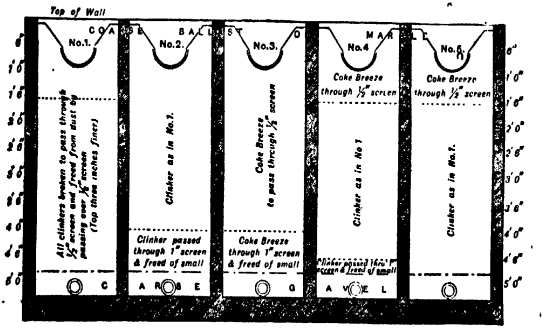

Top of Wall
No.1.
No.2.
No.3.
No.4
No.5.
All clinkers broken to pass through ½" screen and freed from dust by passing over ⅛" screen (Top three inches finer)
Clinker as in No.1.
Coke Breeze to pass through ½" screen
Coke Breeze through ½" screen
Clinker as in No 1
Clinker as in No.1.
Clinker passed through 1" screen & freed of small
Coke Breeze through 1" screen & freed of small
Clinker passed thro' 1" screen & freed of small
0"
1'0"
1'6"
2'0"
2'6"
3'0"
3'6"
4'0"
4'6"
5'0"

FIG. 65—Section showing Arrangement of Filtering Material at Belle Isle.

The flow through the tank is continuous, therefore requires no attention for Sundays or night. The inlet and outlet are submerged so as to minimise the disturbance of the contents. At the far end of the tank a transverse iron pipe, about a foot below the level of the liquid, with a slot on the under surface extending its length, forms an exit for the effluent, which passes over a V-gauge, and then falls in a thin stream over an aerating weir, to restore aerobic conditions. It then flows through distributing channels on to filters of coke breeze or clinker (Fig. 65), four of which are used at a time, and one kept in reserve. An automatic gear devised by Mr. Cameron regulates the cycles of filling, resting full, emptying, and aeration, so that here again no attention is required. (Fig. 64).

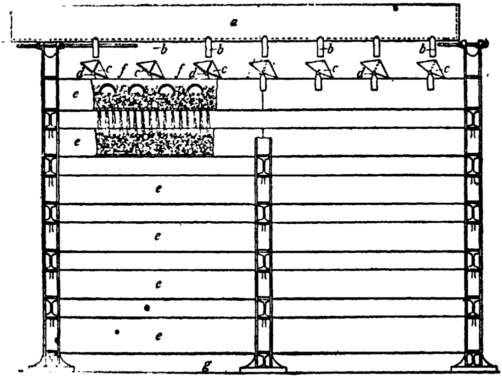


FIG. 66.

By using a series of smaller, separate areas, and passing the effluent continuously and progressively through them, with ample opportunity for the access of the air where it is required, the organisms gradually choose their own conditions, and allied groups gather together at different levels as coatings on the filtering material. In the later sections the nitrifying organisms are almost alone, and are therefore able to exert their full activity. In this way Mr. Moncrieff has secured a much higher nitrification than has been attained by the other processes.

This he has accomplished by spreading the "tank effluent" by tipping troughs or distributors over the uppermost of a series of "nitrifying trays." (See Fig. 66.) The plant in use at Ashstead for a domestic sewage consists of nine perforated trays containing coke, supported vertically over one another at about three inches apart. Each tray has an effective area of one square foot and contains seven inches of coke, broken to one inch diameter. It requires only from eight to ten minutes for the liquid to pass through all the trays (Fig. 66). After the apparatus had been running continuously for three months I collected on two occasions samples from the different trays and examined them separately. The rate of flow was approximately measured as follows :—

	Flow Observed per sq. foot	Equal to Gallons per Acre per 24 hours.
Jan. 25, 1898	1 litre in 15 min.	881,600
Feb. 8, 1898	1,140 c.c. in 12 min.	1,253,400
Mean .	..	1,071,500

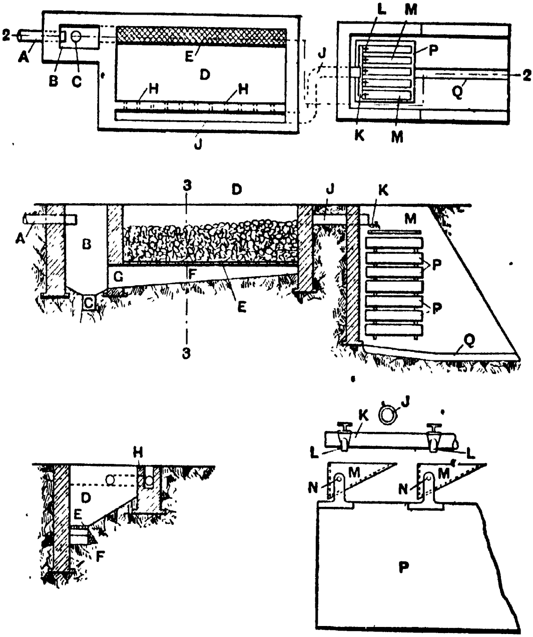


FIG. 67.—Sewage Filter Tank (Scott-Moncrieff).

The progress of the nitration is indicated in the annexed curve (Fig. 68), on which I may offer the following remarks:—

(1) The nitrate has developed with extraordinary rapidity.

(2) The formation of nitrite is much less marked; it rapidly reaches a maximum and then declines.

(3) The free ammonia has been almost completely oxidised; at the same time it was noticed that the original yellowish colour, black suspended matter, and sewage odour had disappeared.*

The following figures give the oxygen

---

* It is stated that "by transposing the trays so as to upset the natural survival of organisms in the sequence the whole process was arrested, a high-coloured and inferior effluent being the immediate result, and one or two days were required to re-establish the conditions that had been disturbed."

relations which I found for the first and last trays :—

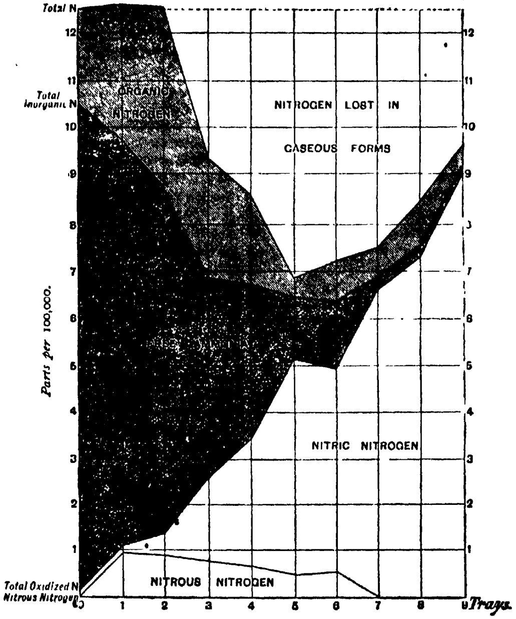


FIG. 68.—Nitrification in Bacterial Trays (Scott-Moncrieff System).

PARTS PER 100,000.

	Dissolved Oxygen cc. per litre.	Oxygen Consumed by Organic Matter.	Available Oxygen.
Jan. 28th—			
Original .	..	9·54	− 9·57
Last tray	..	0·39	+20·1
Feb. 8th—			
Original .	0	9·05	− 9·05
Last tray	6·34	0·44	+12·99

The organic matter has been very greatly reduced for so brief a time of contact. The effluent is now in a state of rapid natural purification by means of its "available oxygen," a term I some time ago proposed for effluents rich in nitrates. We know by the researches of Warington, Munro, Adeney, Gayon, and Dupetit, and others, that the oxygen of a nitrate is utilised for the burning up of organic matter, *provided the latter has been properly fermented*, as in this case it has. In my own experiments I have found that the large loss of nitrogen so often noticed was not accounted for by nitrous acid, ammonia, nor by nitrogen gas. Gayon and others have observed the production of nitrous oxide, which, being soluble, is not evolved, and has no doubt been overlooked by many observers. Therefore, to be on the safe side, I have allowed four atoms of "useful oxygen" to every two molecules of nitric acid, according to the equation :—

$$2HNO_3 = H_2O + N_2O + 4O.$$

Deducting from this the "oxygen consumed" figure, as representing the organic matters which are fairly easy of destruction, I call the surplus "available oxygen," ready to be drawn on to complete the purification. In the above case the quantity is obviously far greater than would be supplied by any process of mere aeration, hence, as I have previously stated, "such an effluent could be easily 'finished' by a fine filter without fouling the latter, or could be beneficially applied to a small area of land, or mixed with a river of moderate volume not only without pollution, but possibly with an actual benefit to the stream."

* * *

SHELLAC.

(*See also* FRENCH POLISH, VARNISH, JAPANS, ETC.)

SHELLAC, as we know it, has its origin in a gum, resin or lac, produced by a small insect (the *Coccus lacca*), which punctures the bark of several kinds of trees (chiefly in India), and after absorbing the fluids found there secretes a gum in which is deposited its eggs. This gum forms a rough-shaped ring or band around the twig, and, in its crude state, is called "stick lac." While the finished product, shellac, is obtained from this, a second and moderately valuable substance is procured at the same time, this being a colouring material known as lac dye, being separated in the production of shellac. The stick lac is seldom seen, as the stick or twig is separated by the native gatherers by beating with a mallet. The pulverised lac thus obtained is the seed lac. The material is then put in large tubs or troughs of water and worked by the feet until the colouring matter is out. The washed lac is then put in a coarse canvas bag, suspended (or held) at each end over a fire, which causes the lac to melt. It is caught in a trough, from whence it is ladled on to a revolving metal roller, usually brass, this causing it to form, in sheets or shells, the shellac as we know it. Its colour may be anything from lemon colour to a deep red. Button lac and garnet lac are both of the same material as shellac, but made of the less pure parts melted up and cooled by throwing on water. Garnet lac, which is very dark, is useful for japanning.

It may be considered that shellac is not soluble in oils. The solvents for shellac will not themselves dissolve in oil, and such recognised solvents as ether, carbon bisulphide and benzene, though soluble in oils, only very slightly dissolve shellac. Shellac is soluble in alkalies, potash, ammonia, etc. but these again will not make a true solution with oil, although an emulsion is possible. The proper solvent for shellac for the majority of commercial purposes (French polish, spirit varnish, etc.) is alcohol in the form of denatured or methylated spirit.

In the process of bleaching shellac it is boiled in a solution of carbonate of potash (pearlash) until dissolved, then chlorine is passed through the solution. This bleaches the shellac and at the same time causes it to be precipitated as an insoluble substance. The shellac is then washed, boiled in water again until pasty, then worked with the hands, pulling it, until it has a satiny appearance. A certain amount of bleaching can be effected by simply boiling the shellac in the carbonate of potash solution, in which case it must be weak and only boiled to the pasty state. The subsequent hand working (pulling, doubling and pulling again) is done the same. (*See* BLEACHING).

Shellac, when stored, should be protected from atmospheric influences. This is of importance, for it can quite lose its nature by exposure. When the lac is prepared it should be broken up, spread on a plate or paper, and set in a moderately warm place to dry. As soon as dry immerse it in the spirit, which may be in a jam-jar or bottle, and place this in another vessel containing water, thus heating it in a water bath, just as glue is melted. Place a cloth over the jar, then subject the water to heat over a low fire or gas ring until the spirit is at blood heat. The lac should then dissolve; if it does not then it should be considered useless for good work.

It may not be generally known that shellac may be dissolved in boiling water, and a water varnish, useful for many purposes, be made in this way: A gallon of boiling water should have 1¼ lb. of shellac put in it to dissolve, and to this is added ¼ lb. borax and ¼ oz. of glycerine. Mix until a proper solution is obtained, then strain through muslin. This varnish is most suitable for basket work, photographic plates, and purposes where a clear easy working varnish is required, but although waterproof it is not suited for exposure to weather. It may, however, be used as a boot varnish. It can be coloured with any dye soluble in water; if black is used this varnish makes a good indelible stencilling ink. The small proportion of glycerine affords elasticity. It is a rapid drying varnish.

* * *

SHOT.

Materials.—Shot, though sometimes made of lead alone, is almost always formed of an alloy of arsenic and lead, the arsenic being introduced in the form of arsenious acid or the sulphide (orpiment). The object of the addition of the arsenic is to slightly harden the lead, and render it capable of cooling to a globular form. Owing to the rapid decomposition of the arsenic, it is treated by itself in the bottom of the melting-kettle shown in Fig. 69. A cover is placed over the substance, and its stem, which rises up through the kettle, is fastened down. The lead is then added above the cover and, when melted, the cover is lifted out of the liquid mass, which instantly becomes permeated by the arsenic beneath. The alloy thus produced contains 45 lb. of arsenic to the ton of lead, and is known as "temper." This again is added in the proportion of 1 per cent. to the pure lead, and thus the shot alloy, containing a very small percentage of arsenic, is produced. The making of quantities of the temper at a time is a great convenience, as the proportion of arsenic in the shot is thus kept uniform, while the melting can be done in the ordinary kettle in the summit of the shot-tower. The temper-pots hold about a ton of metal each, and the cooled product has a brownish gloss distinguishing it in a marked manner from the dull hue of the pure lead.

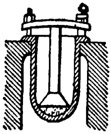


FIG. 69.

Method of Manufacture.—The manufacture of shot was formerly universally conducted in tall brick towers with iron frames, though modern inventions have obviated the necessity for a long drop to cool the shot. In the top chamber is a melting-pot, whence the molten lead is dipped by workmen wearing thick gloves and wielding iron ladles. The metal is poured into colanders, which are simply perforated copper pans, resting in iron rings fastened over the well of the tower. In the bottom of the colander is placed a layer of the dross which rises to the surface of the lead during melting. This in a measure checks the too rapid escape of the melted metal, and is thought to have the effect of increasing the rotundity of the shot, possibly by expediting its cooling as it passes through. The holes in the colanders vary from $\frac{1}{50}$ to $\frac{1}{360}$ inch, but the shot are of larger diameter than the orifices. In falling to the base of the tower, the particles of semi-fluid lead, acted upon alike over their whole surface by a current of air, are made to assume the globular form, and by the time they reach the bottom they are sufficiently hardened by cooling to bear the shock of striking the surface of the water in the well below. The size of the shot is only approximately fixed by the sizes of the holes in the colanders. The mass is always larger than the hole from which it exudes, and as the period of dropping is not exactly uniform, perhaps half-a-dozen sizes are produced from the same sieve. Again, large-sized shot require to be dropped from a greater height than small-sized, and while in some cases 100 feet is sufficient, in others an elevation of 150 feet is hardly enough. Buckshot, as will be explained further on, are not made by the dropping process at all, owing to their size.

Various devices have been proposed for shot-making, having for their object the abolition of the tower. One process consists in pouring lead upon a revolving table on which is placed a cylinder of perforated sheet brass. The table is revolved with a velocity of 1,000 feet per minute on the periphery, and the lead is thrown through the perforations on the side, forming round shot, which strike against a linen screen placed to intercept them. A method has also been patented for dropping shot through short distances, but subjecting them meanwhile to a powerful air-current which cools them.

After the shot have reached the bottom of the well they are at once lifted out by an elevator and thrown upon an inclined drying table, over which they slide, falling ultimately into a wire-gauze rotating cylinder. Here they are rolled and ground together, and in this way the minute burrs upon them are removed. From the cylinder another elevator lifts the shot upon a screening-table, which consists of a series of planes arranged at gradually decreasing heights. Between each two is an interval. The shot, being started at the end of the highest plane, will, if perfect, roll from one plane to another, jumping over the intermediate spaces; if imperfect, however the latter become pitfalls, into which sooner or later, it tumbles, and is carried off into a receptacle, the contents of which go back to the melting-kettle. The good shot, after passing this ordeal, reach the separators. There are usually several tables, each devoted to a different size of shot and its approximating sizes. This is for convenience in future separating. The shot are next elevated to the top cylinder of a series, arranged on an incline. Two of these cylinders are represented in Fig. 70. They are conical in form, inclined, and covered with perforated sheet brass. Each cylinder serves as a sieve for a particular size of shot, retaining that and allowing all smaller sizes to escape. The shot, as the cylinder revolves, traverses its entire length, and then the small ones run out into the next cylinder below, and thus the sifting goes on until each cylinder has picked out the particular class of shot to which it is adapted.

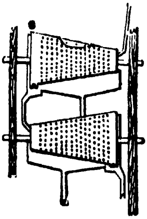


FIG. 70.

The sizes of shot are standard. The smallest is known as "dust," and then comes No. 12, which is 0·05 inch in diameter, 2,326 shot going to the oz. The sizes then increase by hundredths of an inch up to $\frac{23}{100}$, of which there are 24 shot to the oz.

The shot being now assorted, polishing alone remains to be done. This is accomplished by placing the shot together with graphite (plumbago) in a box, which is rapidly rotated. This imparts the glossy black smoothness demanded by sportsmen. The shot are then weighed, bagged, and are ready for commerce.

Buckshot, which range in size from 22 to 38 hundredths of an inch, are moulded. The moulds represented in Fig. 71 consist of a series of pivoted bars, the outer pair of which have handles. The upper edges of these bars are hollowed to form the moulds, so that when they are closed together the opposite halves of each cavity unite, and it is only necessary to pour the lead into the apertures. The shot are thus at once moulded to the proper size, so that tumbling and polishing only are subsequently required.

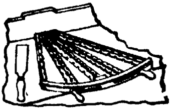


FIG. 71.

* * *

SILVERING.

(*See also* ELECTRO PLATING *and* MIRRORS).

Purifying Silver.—The silver found in the trade, even under the name of virgin silver, retains traces of copper. Silver is purified by several methods:—(*a*) The impure metal is dissolved by nitric acid, and the solution being largely diluted with water, add to it an excess of a filtered solution of common salt. An abundant white precipitate of silver chloride is produced, which rapidly settles to the bottom of the vessel. All the silver salt is decomposed when the clear liquid is not rendered turbid by a further addition of salt. The silver chloride is collected, and washed several times, until the liquors are no longer coloured brown by yellow prussiate of potash. This is the proof that all the copper has been washed out. The washed silver chloride is mixed with two or three times its own weight of soda carbonate, dried, and melted in a crucible. After cooling the metal is found in a conical button at the bottom of the crucible. To granulate it, the molten silver is poured from a height of about 3 feet into a large volume of water.

(*b*) The alloy of copper and silver is dissolved in nitric acid, and the solution is evaporated until the salts fuse. After cooling the fused mass is gradually thrown into a red-hot crucible, when the nitric acid escapes, leaving behind the silver in the metallic state, and the copper as oxide. The separation of the two takes place naturally, and is aided by the addition of dry borax, which dissolves the copper oxide. Silver is easily dissolved in pure nitric acid, but not so rapidly in one contaminated by chlorine or hydrochloric acid, which produces a coat of silver chloride around the metal, and therefore forms an obstacle to its solution. Sulphuric acid also combines with silver, and the resulting salt is but slightly soluble. Pure silver is employed for the preparation of the nitrate and other silver salts, and for soluble anode in silver baths.

Silver Nitrate.—(*a*) Add silver to nitric acid, previously diluted with twice its weight of water, in a flask, and apply a gentle heat until the metal is dissolved, the clear liquor is then separated from any black powder which may be present, evaporated and crystallised. The crystals are dried by exposure to the air, taking care that they do not come in contact with any organic substance.

(*b*) Dissolve the silver in pure nitric acid, and evaporate. The nitrate is yielded in square anhydrous tables. Dissolve this in distilled water, filter, and evaporate again, and the nitrate is obtained pure.

Plating Solutions.—(*a*) Silver nitrate, 1 part; common salt, 1; cream of tartar, 7; powder and mix.

(*b*) Silver nitrate, 1 part; potassium cyanide, 3. Both are applied by wetting with a little water and rubbing on the article to be plated, which must be quite clean. Plating done by the above will be very thin, but it will be silver.

(*c*) Get a glazed earthen vessel, put in 1 oz. nitric acid; place it on a slow fire; it will boil instantly. Throw in some pieces of real silver; this will be dissolved at once. As soon as dissolved, throw in a good handful of salt to kill the acid, then make into a paste with common whiting. The article required to be silvered to be cleaned from grease and dirt, and the paste to be applied with a little water and washleather. This will keep for years.

(*d*) Silver nitrate, 55 parts; solution of ammonia, 60; soda hyposulphite, 100; precipitated chalk, 100; distilled water, 1,000.

(*e*) Dissolve 2 oz. silver with 3 gr. corrosive sublimate; add tartaric acid, 4 lb.; salt, 8 qt.

(*f*) 1 oz. silver nitrate is dissolved in 1 qt. rain or distilled water, and a few crystals of soda hyposulphite are added, which form a brown precipitate soluble in a slight excess of hyposulphite. Small articles of steel, brass, or German silver may be silvered by dipping a sponge in the solution and rubbing it over the surface of the article to be coated. A more concentrated solution may be used for coating parts of articles which have stripped or blistered, by applying it with a camel-hair pencil to the part, and touching the spot at the same time with a thin clean piece of zinc.

Silvering Clock Dials.—Rub the dial with a mixture of silver chloride, tartar, and sea-salt, and afterwards rub off the saline matter with water. This silvering is not durable, but it may be improved by heating the article, and repeating the operation once, or oftener, if thought necessary.

Silvering Iron.—(*a*) 15 grm. silver nitrate are dissolved in 250 grm. water, and 30 grm. potassium cyanide are added; when the solution is complete the liquid is poured into 750 grm. water, in which 15 grm. common salt have been previously dissolved.

(*b*) Cast-iron intended to be silvered by this solution should, after having been well cleaned, be placed for a few minutes in a bath of nitric acid of 1·2 sp. gr., just previous to being placed in the silvering fluid.

(*c*) Polish the surface very clean and level with a burnisher; then expose it to a blueing heat; a leaf of silver is to be properly placed and carefully burnished down. This is repeated until sufficient leaves are applied to give the silver a proper body.

(*d*) By solder. Slips of thin solder are placed between the iron and silver with a little flux, and secured together by binding wire. Then place in a clear fire until the solder melts; when it is taken out, on cooling, the silver will adhere firmly.

(*e*) By tinning the iron first and uniting the silver by means of slips of rolled tin, brought into fusion in a gentle heat.

(*f*) A manufacturer in Vienna employs the following process for silvering iron. He first covers the iron with mercury, and silvers by the galvanic process. By heating to 570° F. the mercury evaporates and the silver layer is fixed. Ironware is first heated with dilute hydrochloric acid, and then dipped in a solution of mercury nitrate, being at the same time in communication with the zinc pole of an electric battery, a piece of gas carbon or platinum being used as an anode for the other pole. The metal is soon covered with a layer of quicksilver, and is then taken out and well washed and silvered in a silver solution. To save silver the ware can be first covered with a layer of tin; 1 part cream of tartar is dissolved in eight of boiling water, and one or more tin anodes are joined with the carbon pole of a Bunsen element. The zinc pole communicates with a well-cleaned piece of copper, and the battery is made to act till enough tin is deposited on the copper, when this is taken out and the ironware is put into its place. The ware thus covered with tin chemically pure and silvered is much cheaper than any other silvered metals.

Plated Silver Reflectors.—A bath made of water, 1¾ pint; silver nitrate, 2 oz.; potassium cyanide, 10½ oz. Add sufficient Spanish white, or levigated chalk, in fine powder to produce a thin paste, which is kept in a well-closed pot. This paste is spread by a brush or pad of old linen all over the surface of the reflector, and allowed almost to dry, when it is briskly rubbed over by another clean dry rag of old linen.

Silvering on Solder.—The difficulty of obtaining regular deposits of silver over articles which have parts soldered may be greatly obviated by scratch-brushing those parts dry, that is, without the usual liquid employed. This renders these refractory parts better conducting, provided that during the operation no impurities are left on these spots.

Silvering Thermometer Scales.—Take ½ oz. silver nitrate;

dissolve in half a tea-cupful of cold water ; add ½ lb. cream of tartar, with 1½ lb. common salt beaten or ground fine. Mix and stir well together, adding water until it attains the consistence of a thick paste. Now lay the scale on a board, the brass or copper being previously well cleaned and cast off from fine sand-paper ; rub the silvering on with your hand until it attains the appearance of silver, which will be a minute or so ; now take the work off the board and rub a little wet whiting over it, wash out in clean cold water, and dry in sawdust. If varnished with a thin coat of white hard varnish, reduced in spirits of wine, this will last for years. The above quantity of silvering, used with care, will silver six dozen brewers' thermometers 14 inches long.

De-silvering.—(*a*) The following liquid will dissolve silver without attacking copper, brass or German silver, so as to remove the silver from silvered objects, plated ware, etc. It is a mixture of 1 part nitric acid with 6 parts sulphuric, heated in a water-bath to 160° F., at which temperature it operates best.

(*b*) Mix sulphuric acid, 1 part ; nitric acid, 1 ; water, 1 ; boil the metal in the mixture till it is dissolved, and throw in a little salt to cause the silver to subside.

(*c*) Nearly fill a flat pan of enamelled cast iron with concentrated sulphuric acid, and heat to a temperature of 300°-400° F. ; at the moment of using it pinches of dry powdered saltpetre are thrown into it ; then hold the article with copper tongs in the liquid. The silver rapidly dissolves, and the copper or its alloys are not sensibly corroded. According to the rapidity of the solution, more or fewer pinches of saltpetre are added. All the silver has been dissolved when, after rinsing in water and dipping the articles into the cleansing acids, they present no brown or black spots, that is, when they appear like new metals.

(*d*) For removing the silver from wrought and cast iron, zinc, or lead, it is preferable to invert the electric current in a cyanide bath, or to use mechanical processes. Old desilvering liquors become green after use ; to recover the silver they are diluted with four or five times their volume of water, then add hydrochloric acid or common salt. The precipitation is complete when the settled liquor does not become turbid by a new addition of common salt or hydrochloric acid. The resulting silver chloride is separated from the liquid either by decantation or filtration, and is afterwards reduced to the metallic state.

(*e*) For dissolving silver in the cold the objects are hung in a large vessel filled with the following mixture :—Sulphuric acid at 66° B., 10 parts ; nitric acid at 40° B., 1, in which they remain for a greater or less length of time, according to the thickness of the coat of silver to be dissolved. This liquid, when it does not contain water, dissolves the silver without sensibly corroding copper and its alloys ; therefore avoid introducing wet articles into it, and keep the liquid perfectly covered when not in use. As far as practicable, place the articles in the liquid so as not to touch each other, and in a vertical position, so that the silver salt will fall to the bottom. In proportion as the action of the liquor diminishes pour in small and gradual additions of nitric acid. Dissolving silver in the cold is regular and certain, but slow, especially when the proportion of silver is great.

Hot Silvering.—(*a*) Dissolve 1 oz. silver in nitric acid ; add a small quantity of salt ; then wash it and add sal ammoniac, or 6 oz. salt and white vitriol ; also ½ oz. corrosive sublimate ; rub them together till they form a paste. Rub the piece which is to be silvered with the paste, heat it till the silver runs, after which dip it in a weak vitriol pickle to clean it.

(*b*) For small articles a bath is made by dissolving in an enamelled cast-iron kettle in 2 gal. water, 17½ oz. ordinary potassium cyanide. Also dissolve 5¼ oz. fused silver nitrate in 1¾ pint water contained in a glass or porcelain vessel. The second solution is gradually poured into the first. Stir with a glass rod. The white or greyish-white precipitate produced soon dissolves, and the remaining liquor is filtered if a perfectly clear bath is desired. When brought to the boiling-point, it will immediately silver the cleansed copper articles plunged in it. The objects must be quickly withdrawn. The silvering should immediately follow the cleansing, although the rinsings after each operation should be thorough and complete. This bright and light silvering is adapted for set jewellery, which cannot be scratch-brushed without flattening the clasps, and to which a bright lustre is absolutely necessary as a substitute for the foil of burnished silver placed under the precious stones of real jewellery. The employment of the solution of nitrate of binoxide of mercury is useless, and even injurious, for this bath. It is useless to keep up the strength of the solution by new additions of cyanide and silver salt; thus reinvigorated it gives results far inferior to those of the former solution. The bath should, therefore, be worked out as long as the silvering is satisfactory, and when exhausted, put away with the waste. With this process a battery and a soluble anode may be used to obtain a more durable deposit.

(*c*) A solution which, when boiling, produces a very fine silver coat, with a dead, or partly dead lustre, upon cleansed coppers, is made by dissolving with the aid of heat, in a well-scoured copper kettle, distilled water, 9 pints; potassium ferrocyanide, 21 oz.; potash carbonate, 14 oz. When the liquid boils, add the well-washed chloride obtained from 1 oz. pure silver. This should boil for about ½ hour, and be filtered before using; part of the silver deposits upon the copper kettle, and should be removed when a new bath is prepared. On account of this inconvenience, the process has been nearly abandoned, although the products are remarkably fine. All the dipping silvering baths, which contain a comparatively great excess of potassium cyanide to the proportion of the silver salt, will silver well copper articles perfectly cleansed, even in the cold; whereas this property diminishes in proportion to the increase of the amount of silver in the bath, or with the decrease of the amount of cyanide.

(*d*) For small articles, partly copper and partly iron, such as those used for saddlery and carriage wares, a particular process of silvering is used. The bath is composed of: Water, 9 pints; caustic potash, 6 oz.; potash bicarbonate. 3½ oz.; potassium cyanide, 2 oz.; fused silver nitrate, ⅜ oz. The cyanide, caustic potash, and bicarbonate are dissolved in 7 pints of water in an enamelled cast-iron kettle, then the remaining quart of water, in which the silver nitrate has been separately dissolved, is added to the former solution. For the silvering operations, the articles are cleansed, thoroughly rinsed, and put into a small enamelled kettle. Enough of the silver bath is poured in to cover the articles entirely, and the whole is brought to a boil for a few seconds, and stirred with a wooden spatula. When the silvering appears satisfactory, the liquor employed is put with the saved waste; the same liquid is never used for two batches of articles. This process gives a somewhat durable silvering with a dead lustre, of a greyish-white, which is increased in whiteness and brightness by soap and burnishing.

Silvering with Foil.—This method is never practised except upon objects already manufactured, in their definite shape, and is adopted to all kinds of copper, bronze, or brass. It is, in certain respects, superior to plated silver, but is very difficult of execution, and has less adhesion to the metal underneath. After annealing the articles, they are thrown whilst hot into a bath of sulphuric acid with a small proportion of hydrochloric and nitric acids. They have then a dull and dead lustre, owing to a multitude of small holes, which are so many points of attachment for the silver foil. The objects, thus prepared, are tightly fixed upon an iron rod, which is held in a vice. Their temperature is raised to about 300° F., by means of incandescent charcoal put at the proper place, so as to open the pores of the metal, which, by cooling afterwards, will imprison the silver applied. The silver foils, taken from the book with small tweezers, are cut to the proper size upon a cushion with an ivory or steel knife. After each foil is deposited upon the object, it is made to adhere by a light pressure of a rag pad, and afterwards by the friction of a steel burnishing tool. The parts of the silver foil which do not adhere are removed with a soft brush. Gold-beaters prepare silver foil either with bright or dead lustre. The latter is made to adhere only by the pressure of the pad, and not by the burnishing tool. This dead lustre cannot compare in fineness with that obtained by the battery; however, it resists handling and the sulphur gases of the atmosphere better. Articles thus silvered are only burnished after all the silver foils have been applied; round or cylindrical objects are burnished upon the lathe, other forms by the hand; there are always places and lines showing the vibrations of the burnishing tool. This method of silvering is only employed for very large objects, such as high chandeliers and other church ornaments. Spoons and forks may be covered with silver foil, as follows:—First slightly silver with a dead lustre in a silver bath by dipping; heat, and then cover with silver foil, by the pressure of an iron scratch-brush striking vertically, forcing the silver foils into the pores of the metal underneath. Burnish by the usual method; it is impossible to obtain a dead lustre by this method.

Whitening with Silver in a Pot.—This operation is still employed for whitening small ware for which durability is of secondary importance, and which simply require the whiteness of silver; such as hooks and eyes, or buttons. This whitening is made as follows:—(*a*) Dissolve a certain quantity of pure granulated silver in double its weight of pure nitric acid. The solution is largely diluted with water, and the metal is precipitated in heavy white clods by common salt or hydrochloric acid. All the silver nitrate has been decomposed when a further addition of hydrochloric acid or common salt to the clear supernatant liquid does not produce any turbidity. The clear liquors are then thrown away, and the silver chloride obtained is washed several times, to deprive it of all free acid. If this precipitate is to be kept some time before use it should be removed from the sunlight, which blackens it rapidly. The silver chloride, with a little water, is thoroughly mixed with at least 80 times its weight of finely powdered potash bitartrate, and kept in a stoneware pot.

(*b*) Pure silver for making the chloride, 1 part; powdered cream tartar, salt, 83 parts each; a few spoonfuls of the paste thrown in, and dissolved in boiling water contained in a pure copper kettle. The articles are dipped into this bath by a hook, or in a basket of wire gauze. Or have another basin of copper, shallow and perforated with holes, which rests against the upper sides of the kettle. By means of handles, this basin can be removed at once with its contents. Stir the articles with a wooden spatula; and at each operation add a quantity of paste, proportioned to the surfaces to be whitened. These baths do not work well when freshly made, but improve as they are more used. They acquire a dark green tint, due to the copper which is dissolved, and which takes the place of the deposited silver. Varnishing, colouring, and cleansing may be done in aquafortis; but these cleansing methods are inferior to those employed for gilding; in general, use the worn-out acids of gilders. Brighten the articles by friction with saw-dust. The smallest particle of iron, zinc, or tin introduced into the whitening-bath imparts a red colour to the brass or copper articles in the liquor. The iron is separated by a magnet; the zinc is dissolved in pickles of hydrochloric or sulphuric acid, which, when cold, do not sensibly corrode the copper articles; tin or lead must be picked out by hand. If the operation has not succeeded, the articles are plunged for a few seconds into a boiling solution of water, 2⅕ gal.; silver nitrate, 3½ oz.; ordinary potassium cyanide, 21 oz. This bath retains its strength for a long time, and increases the brightness and whiteness of the deposit. The process of silvering by dipping has nearly superseded this method.

Silvering Powder.—(*a*) Take 40 gr. silver dust; cream of tartar, 3 dr.; common salt, 2 dr.; and 40 gr. powder of alum. Polish any silver articles with this powder and a soft leather.

(*b*) Silver nitrate, 30 gr.; common salt, 30 dr.; cream of tartar, 3½ dr. Mix, moisten with water, and apply.

Plated Silver is obtained by rolling together a plate of copper of the first quality, and one of silver; these are either welded, or simply united by placing their hot and clean surfaces together, wetted with a concentrated solution of silver nitrate. The two metals are reduced and drawn out about equally by the pressure of rolls, and long sheets or bands of silvered metal are thus obtained, with which a great many articles may be manufactured. By this mode of operation, a great quantity of material is lost, as the objects have to be cut out from a sheet entirely silvered, and the waste retains a large proportion of that metal; the cut sections present parts without silver, which must be hidden by ledges, or by silvering by another method. There is also the absolute necessity of employing pure copper, which is more costly, less sonorous, and not so tough as its alloys; but the greatest defect of the process is the difference of thickness of the silver, according to the shape of the object. Raised surfaces are the most exposed to friction, and it is just there that the coat of silver is the thinnest; the conditions are reversed with electro-silvering, and the parts in relief receive a more abundant deposit of silver, which is a satisfactory result. The best plated silver is manufactured by applying upon an ingot of pure copper weighing 9 parts, another ingot of pure silver weighing 1 part, to coat one side only; add another part of silver, if it is intended to coat both sides. The two are rolled together until the desired thickness is obtained. The silver of the plated metal will be bright if the rollers are well polished, and dull with rough rollers. The only solder which does not injure plated silver is tin solder; and when the objects manufactured are required to resist a warm temperature, nuts and screws are employed.

(*a*) The electroplating of old wares made from copper with a covering of silver is often difficult. Supposing it is required to electroplate an old cruet-stand, the bottom is separated from the wire, either by unsoldering or unscrewing. Smooth by emery cloth, or pumice and water, or by powdered bath-brick brushed over with a hard brush. Spots of verdigris are removed with a few drops of hydrochloric acid. The great difficulty consists in giving a good electro-deposit upon the edges or mounts where there may be some lead or lead solder; apply to such parts with a rather soft brush a solution made by dissolving 4 oz. mercury in nitric acid and adding about ½ pint cold water This solution is lightly brushed over the lead mounts only; the article and brush are then well rinsed, and the brush and plain water are applied in the same way. The solution of mercury will turn the edges black, or dark grey, but the subsequent brushing will render them bright again. The frame when well rinsed is ready for the depositing bath. If, on its first immersion, any black spots appear, the frame may be removed, again brushed over, and finally returned to the bath. If the edges do not receive the coating of silver as readily as the other parts, the solution may require a little more cyanide, or a greater battery power, or an increase in the surface of the anode. These lead edges may be prepared for receiving the silver deposit by a previous coat of copper applied as follows: The edges are plunged into a solution of copper sulphate, with a little free sulphuric acid in it; then, by touching the lead edge with an iron wire, it is immediately coated with a bright deposit of copper, which is rinsed and becomes a good conductor for the further electro-deposit of silver. The coating of tin underneath the bottom of cruet frames is very difficult to plate, unless in a solution made expressly for it; therefore it is preferable to remove it either with abrading materials, or with nitric acid employed with care. This process of depositing copper will be found useful not only for old plated ware, but also for many articles on which are found unruly spots of tin solder.

(*b*) Oxidised parts and gilding may be put upon the same article by the following method: After the whole surface has been gilt, certain portions are covered with the resist varnish; silver the remainder. Should the process of silvering by paste and cold rubbing be employed, the gilding should be very pale, because it is not preserved, and is deeply reddened by the sulphur liquor. When this inconvenience occurs from a too concentrated liquor, it is partly remedied by rapidly washing the article in a tepid solution of potassium cyanide.

(*c*) Deep black is thus obtained upon cleansed copper: Dissolve 3-4 oz. blue ashes (copper hydrocarbonate) in a sufficient quantity of aqua ammonia, place the cleansed copper in this solution, cold or tepid; it will be instantaneously covered with a fine black deposit. This coat is so thin that burnished articles look like varnished black.

(*d*) Oxidise silver-plated articles by dissolving copper sulphate, 2 dwt., potash nitrate, 1 dwt., and ammonia muriate, 2 dwt., in a little acetic acid. Apply with a camel-hair pencil; but warm the article first, and expose it to the fumes of sulphur in a closed box; the parts not to be coloured must be coated with wax.

Silvering Brass.—(*a*) Take ¼ lb. potassium cyanide and ½ oz. silver nitrate; dissolve all the cyanide in 16 oz. distilled or boiled water, and the silver in a similar quantity in another vessel. Into the vessel containing the silver, throw a spoonful of common salt; stir this up well with a clean piece of wood and let it settle; dissolve some salt in water, and after the silver solution is settled mix a few drops of the salt water in it. If there is any cloudiness formed it proves that all the silver is not thrown down; more salt must be added, and then stir and allow to settle. If the addition of salt water has no effect, the water may be decanted off, carefully preserving the white deposit. Now pour some boiling water on this deposit; let it settle, and pour off as before. Do this at least three times; pour off as dry as possible, and add about 1 pint clean water, and then by ½ oz. at a time the cyanide solution, till all the white precipitate is dissolved; add enough water to make ½ gal. Stir well after each addition of cyanide solution. If on dipping the article, which must be well cleaned with brick-dust and water, into this solution the silver deposits immediately and in a dark powder, it must be weakened by adding more water; if it coats slowly, more white precipitate must be prepared, washed, and added to it. This must also be done when the solution is getting short of silver. It works best at about 60°-70° F.; a dry, warm room suits the operation. Brass and copper only can be silvered; other metals require a battery. This method gives a beautiful result when the work is polished and burnished.

(*b*) Clean the articles thoroughly, and then immerse them for a few seconds in a solution of silver cyanide, which will plate them without any further trouble. C.

(*c*) A silvering solution, which will cover brass, German silver, and copper with a thin but substantial film of silver, may be made by adding to a strong solution of silver nitrate sufficient of a solution of potassium cyanide to redissolve the precipitate at first thrown down. Mix in with this sufficient Spanish whiting or precipitated chalk to make a thin paste. This solution, to obtain its best effect, should be slightly warmed before application, and the articles to be silvered should be clean and free from grease. By scattering or rubbing zinc filings over the surface to be silvered, especially if it be of copper, a much more beautiful effect is produced, the filings being washed off after the silver coating is obtained.

(*d*) To coat copper or brass objects with silver, without difficulty or loss of time, mix 3 parts silver chloride with 20 of powdered cream of tartar and 15 of powdered common salt. Moisten a suitable quantity of the mixture with water, and rub it with a piece of blotting paper upon the metallic object, which must be thoroughly clean. The latter is afterwards rubbed with a piece of cotton upon which precipitated chalk is dusted, then washed with water, and polished with a dry cloth.

Silvering-paste for Brass.—This may be used for clock-dials, barometers, metal-fronted thermometers, etc. Put in an earthenware cup an ounce of silver, pure silver if obtainable, but coin silver will do. Fill the cup half-full of nitric acid, then stand it in a saucepan of water to be heated. As the heating takes place brown fumes will come off; these must not be breathed. When the fumes cease, add a teaspoonful of table-salt. Fuming will re-commence, but soon cease. The cup is then at once taken from the heat and filled very slowly with cold water. A white powder will form; allow this to settle to the bottom, then slowly decant the liquid. When almost empty, fill again with cold water, and decant again, repeating this process at least half a dozen times. Mix the powder (commercial chloride of silver will do instead) with 10 lb. table-salt and ½ lb. cream of tartar. Mix thoroughly dry, then add enough cold water to make a paste. Add the water slowly, so as not to get in too much. Keep in a covered vessel, and from the light.

The piece to be silvered should be thoroughly cleaned with emery cloth or paper just before applying the paste, which is to be put on by hand and rubbed well in the surface of the work. After this is done, the work should have a dirty, silvery yellow tinge, which will be brightened by rubbing with a dry mixture of ½ lb. of cream of tartar and 10 lb. salt well mixed. The work should be thoroughly washed to clear it of the surplus salt, and then dried in sawdust and lacquered.

Cold Silvering.—(*a*) 2 dr. tartar, 2 dr. common salt, ½ dr. alum, and 20 gr. silver, precipitated from the nitrous acid by copper. Make into a paste with a little water. This is to be rubbed on the surface to be silvered with a cork.

(*b*) Dissolve pure silver in aquafortis and precipitate the silver with common salt; make this precipitate into a paste by adding a little more salt and cream of tartar. It is applied as in (*a*).

(*c*) A stoneware or glass vessel is about three parts filled with liquid soda bisulphite; a solution of silver nitrate in distilled water, of medium concentration is gradually added while the bath is continually stirred with a glass rod; a white flocculent precipitate of silver sulphite is produced by stirring; this is dissolved by the soda bisulphite. The silver solution is added so long as the precipitate readily disappears, and stopped when it becomes slow to dissolve. This bath is always ready to work, and instantaneously produces a magnificent silvering upon copper, bronze, or brass articles which have been thoroughly cleansed and passed through a weak solution of nitrate of binoxide of mercury, although this last operation is not absolutely necessary. The loss of silver is made good by additions of silver nitrate. When the proportion of the bisulphite is not sufficient to dissolve the metallic salt, add some soda bisulphite to restore the bath to its primitive state. Silver is slowly deposited upon the sides of the vessel; this may be dissolved in nitric acid for future uses.

As the bath is cold it is always ready for use, and the deposit is finer and more unalterable, because only chemically pure silver is deposited, without any mixture of subsalts. Bisulphites of potash, ammonia, and other alkalies may be substituted for the soda bisulphite, but the latter is to be preferred because it is cheaper.

(*d*) By rubbing, with the thumb, a cork, or a brush. The results are better than those by the whitening process, but not very durable; the method is useful to repair slight defects upon more durable silverings, and to produce mixtures of gold and silver, or gold, upon slightly gilt objects, thus avoiding the use of resist varnishes. Make a paste by thoroughly grinding in a porcelain mortar or with a muller, and, as far as practicable, not in the light—(1) Water, 3½–5 oz.; white fused silver nitrate, or, preferably, chloride, 7 oz.; potash binoxalate, 10½ oz.; potash bitartrate, 10½ oz.; common salt, 15 oz.; sal ammoniac, 2¾ oz. (2) Silver chloride, 3½ oz.; potash bitartrate, 7 oz.; common salt, 10½ oz. When finely pulverised in a porcelain mortar, triturate it under a muller, upon a plate of ground glass until there is no granular feeling. Keep the paste in a porcelain pot, or in a black glass vessel, to preserve it from the light, which decomposes it rapidly. When about to use it, add a little water so as to form a thin paste, which is applied with a brush or pencil upon the cleansed articles of copper, or upon those gilt by dipping, or even upon those gilt by the battery, provided that the coating is thin enough to allow the copper to decompose the silver paste through the coat of gold; allow the paste to dry naturally, or with the aid of a gentle heat. The chemical reaction is more or less complete according to the thickness of the gold deposit, and the dry paste is of a pink shade, or entirely green. The salts are removed by a thorough rinsing in cold water, and the silver appears with a fine frosted appearance, the brightness of which may be increased by a few seconds' immersion in a very dilute solution of sulphuric acid, or potassium cyanide. This silvering bears the action of the wire brush and of the burnishing tool very well; and it may also be oxidised. Should a first silvering not be found sufficiently durable after scratch-brushing, apply a second or a third coat. This silvering is not so adhering or white on pure copper as upon a gilt surface. For the reflectors of lanterns the paste is rubbed upon the reflector with a fine linen pad; then, with another rag, a thin paste of Spanish white, or similar substance, is spread over the reflector and allowed to dry, Rubbing with a fine and clean linen rag will restore tho lustre and whiteness of the plated silver.

Preparing Soda Bisulphite for Cold Silvering.—Put into a tall vessel of glass or porcelain, water, 10 pints; crystallised soda carbonate, 10 lb. Pour a little mercury into the bottom of the vessel, so that the glass tube carrying sulphurous acid gas, which has to be placed in it, may not be stopped by the crystals formed during the operation. Arrange an apparatus for the production of sulphurous acid gas, and let the washed gas pass through the vessel holding the soda carbonate. Part of the soda is transformed into sulphite, which dissolves, and a part falls to the bottom as bicarbonate. The latter is, however, transformed into sulphite by a continuous production of sulphurous acid, and the carbonic acid escapes. When all has dissolved, continue the passage of sulphurous acid until the liquid slightly reddens blue litmus paper, and then put the whole aside for 24 hours. After that time, some crystals are found upon the mercury, and the liquid above, more or less coloured, is the soda bisulphite for silvering. The crystals are separated from the mercury, drained, and kept for gilding baths. They are not suitable for silvering. The liquid soda bisulphite should be stirred with a glass rod, to throw off the carbonic acid which may still remain. The liquor should then be again tried with blue litmus paper. If it turns a deep red, add a little soda carbonate for neutralising the excess of sulphurous acid; if red litmus paper becomes blue, there is too much alkali, and more sulphurous acid gas should be passed through the liquid, which is in the best condition when litmus paper becomes violet or slightly red. This solution marks 22°–26° B. and must not come in contact with iron, zinc, tin, or lead.

Nielled Silver.—This is a kind of inlaid enamel work, and is obtained by the sulphuration of certain parts of a silver object. But instead of being direct, this is produced by inlaying the silver surface with a sulphide of the same metal prepared beforehand. For preparing the niel, heat a certain proportion of sulphur in a deep crucible; heat a certain quantity of silver, copper, and lead in another crucible, and when melted pour into the fused sulphur, which transforms these metals into sulphides; then add a little sal ammoniac, remove from the crucible, pulverise for use. First crucible—flowers of sulphur, 27 oz.; sal ammoniac, 2¾ oz. Second crucible, which after fusion is poured into the first—silver, ½ oz.; copper, 1½ oz.; lead, 2¾ oz.

(*a*) After having reduced the niel to a fine powder, mix with a small proportion of a solution of sal ammoniac, hollow out the engraving upon a silver surface, and cover the whole, hollows and reliefs, with the composition. The article is then heated in a muffle until the composition solders to the metal. Uncover the pattern by a level polish, when the silver will appear as over a black ground. This method is costly, as each article must be engraved.

(*b*) Engrave in relief a steel plate, and press it against the silver plate between two hard bodies. The copy is hollow, and ready to receive the niel. A great many copies may be obtained from the same matrix.

Old Silver.—To imitate old artistic productions made of solid silver, the groundwork and hollow portions not subject to friction are covered with a blackish-red earthy coat, the parts in relief remain with a bright red lustre. Mix a thin paste of finely-powdered plumbago with essence of turpentine, to which a small proportion of red ochre may be added to imitate the copper tinge of certain old silverware; smear this all over the articles. After drying, gently rub with a soft brush, and the reliefs are set off by cleaning with a rag dipped in spirits of wine. Old silver is easily removed, and the brightness of the metal restored, by a hot solution of caustic potash, potassium cyanide, or benzole. To give the old silver tinge to small articles, such as buttons and rings, throw them into the above paste; rub in a bag with a large quantity of dry fir-wood saw-dust until the desired shade is obtained.

Oxidised Silver.—(*a*) This is not an oxidation, but a combination with sulphur or chlorine. Sulphur, soluble sulphides, and hydrosulphuric acid blacken silver, and insoluble silver salts, and particularly silver chloride, rapidly blackens by solar light. Add four or five thousandths of ammonia hydro-sulphate, or of potassium quintisulphide, to ordinary water at a temperature of 160°–180° F. When the articles are dipped into this solution, an iridescent coating of silver sulphide covers them, which after a few seconds more in the liquid turns blue-black. Remove, rinse, scratch-brush and burnish when desired. Use the solution when freshly prepared, or the prolonged heat will precipitate too much sulphur, and the deposit will be wanting in adherence; besides the oxidation obtained in freshly-prepared liquors is always brighter and blacker than that produced in old solutions, which is dull and grey. If the coat of silver is too thin, and the liquor too strong, the alkaline sulphide dissolves the silver, and the underlying metal appears. In this case cleanse and silver again, and use a weaker blackening solution.

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SLAG PRODUCTS AND SLAG WOOL.

As blast-furnace slag consists almost wholly of silica, lime and alumina (approximately in the volumes of 3·3 and 1 respectively) it is to be wondered at that some really great use has not been discovered for it. The available amount is practically inexhaustible, and it is to be had for nothing, or less (for its disposal has now to be paid for in most cases). As will be shown, there are several good uses it is being put to, but, as yet, the quantity so disposed of is comparatively trifling.

The disposal of the enormous output of slag or scoria from blast-furnaces has always been one of the serious difficulties of the iron trade. Taking an average of all the districts in England, for each ton of iron made, 25 cwt., of slag is produced; and from the official returns of 1879 of the iron smelted, no less than 8,000,000 tons of slag were produced. The space occupied by this mass, when loosely tipped, is something like 170,000,000 cub. ft., whilst the bulk of the iron occupies only ⅛ of the same space. There is, however, this great difference between iron and its refuse, that whilst the former is diffused and finds it way into every corner of the world, the latter is left behind at the smelting-works, absorbing something like 250,000*l*. annually in its disposal, and destroying hundreds of acres of valuable agricultural land. While we produce such enormous quantities of iron, so long will these heaps go on accumulating; and there is little chance that existing masses will ever be turned into a marketable product. At the same time, blast-furnace slag possesses many valuable properties, which may in certain localities be converted into things useful to the arts and sciences, and at considerable profit.

Of other slags produced in metallurgical operations—such as in the smelting of copper, lead, zinc, and tin ores

—no use is made; but there are also slags, or cinders, produced in the manufacture of wrought iron, some of which are re-smelted, after which no great bulk of refuse is left.

Blast-furnace slag, as it flows from the furnace when making foundry iron, is usually of a grey colour, of much the same consistency as molten glass, a substance, in many points, it greatly resembles, particularly when the more siliceous ores are being smelted. It is very fluid, and has a temperature considerably above the melting-point of cast iron; in proof of which, if a piece of cold cast iron be placed in a block or wagon of fresh molten slag, it readily melts. At this high temperature it contains a large quantity of gas, a considerable portion of which is thrown off or exuded as the slag cools down or becomes set. So much is this the case, that a large "block" or "ball," technically so termed, will often burst, an hour or two after being run, from the accumulation of this gas in the inside. The bursting of these balls at the iron-works is of constant occurrence, and a source of danger, caused by the liquid slag and the outside shell dropping after the ball has burst. This is partially overcome by making the workman knock a hole through the top crust before leaving the furnaces. Again, the least dearrangement in working the furnace is quite sufficient to alter the nature of the slag, and often, within ½ hour, will the slag be changed from grey to a perfect black. Such a colour usually indicates imperfect smelting, and the slag will be found to contain a larger proportion of iron than it should do.

Road-Metal.—For many years the only known use for blast-furnace slag was in road-making, and for this purpose it is still largely employed. In Northamptonshire, and in certain districts of Yorkshire, the whole of the slag produced is sold at a considerable profit. These, however, are local exceptions. Large quantities of slag are used in the works on the breakwater at the Tees mouth, something like 500,000 tons annually. A similar class of work is carried on at Barrow-in-Furness, from the slag produced at the hematite furnaces in that town; but in consequence of the large amount of lime contained in this slag, much greater care has to be taken in its selection. The slag used at the Tees breakwater is chiefly taken away upon bogies, in blocks weighing 3½ ton each. The slag is run into these blocks upon the waggons at the furnaces, a case or box being placed upon the bogie for this purpose. When the slag is sufficiently "set," this case is removed, and the wagon, with the block upon it, is taken a distance of about six miles to the breakwater. A large quantity is also tipped upon a platform on the river-side, in such a position that the tide completely covers it; it is then wheeled into hopper barges. Fowler and Wood devised a plan for shipping the bogies with the hot balls into barges, and towing them down the river for discharging; each barge is constructed to carry 40 bogies and is about 220 tons burden.

Castings.—The next stage in slag utilization is the endeavour which has at various times been made to run the liquid slag, as it flows in a stream from the furnace, into moulds; or, in other words, making slag castings. Such an idea at first sight would seem natural enough. Here, it may be said, is a material flowing to waste, in a liquid state, capable of being run into moulds, and of taking impressions almost equal to those of cast-iron. The castings also, when successfully made, are exceedingly durable, and even beautiful to look at. So alluring has been the idea of casting, that during the last fifty years the Patent Office has recorded almost annually the attempts of some inventor impressed with the notion that he could treat this treacherous fluid successfully. To describe these various schemes, or to give even an outline of them, would occupy too much space, but the following remarks will afford a general idea of the difficulties.

The high temperature at which the slag leaves the furnace has been before noticed—namely about 3000° F. (1727° C.), but, when it is brought into contact with anything cold, in the shape of a mould, it readily parts with its heat, and, in so doing, suddenly contracts. The surface contracting, becomes filled with fine cracks or flaws; so much is this the case that, if allowed to assume entire consolidation in the moulds, these cracks will be found to penetrate completely through the casting, and upon exposure to the air the casting falls to pieces. This is the more vexing as, when slag is run into a large mass—say into a pit of sand 8 or 10 ft. deep, and containing 30 to 40 tons—there is such an enormous amount of heat accumulating that it becomes self-annealing, the outside of the mass is kept at a high temperature, and, if allowed to remain until cool, not a flaw will be found, and the slag becomes so tough and hard that it may be quarried in the same way as granite or whinstone, and used for street paving.

Paving Blocks.—There is, however, one exception to the numerous failures in slag-casting. It is known as Woodward's patent, and, although there is absolutely nothing new in the process, still, through the preseverance of Dobbs, the late manager and engineer for the furnaces of T. Vaughan and Co., an amount of success has been arrived at, sufficient to enable the company which works the process to pay a fair dividend. The success has been eminently a practical one, and appears to rest mainly upon two points:—Firstly, in the quickness with which the castings are removed from the moulds, and placed in the annealing ovens, where the temperature is constantly kept up nearly as high as the melting-point of slag, the heat, after the ovens are full, being so gradually lowered that the outside of the casting cools at the same rate as the inside; the contraction is thus equalized throughout, strains upon the outside are avoided, and the fine surface cracks do not penetrate much below the skin. And secondly, upon the fact that only solid rectangular blocks, with a certain amount of bulk in them, are attempted.

At one works blocks are made by running the liquid slag into a series of open-topped moulds. The moulds are of cast-iron, and are held by one end upon the periphery of a horizontal wheel or table. The wheel is suspended by tie-rods upon a central pillar. The moulds, when being filled up, are brought in succession under the slag-runner by the man in attendance, who watches until the mould is full. When the slag has become consolidated in the moulds, a catch-hook is knock up, the moulds fall to pieces, and the bricks drop to the ground. When they come out of these moulds, although consolidated, they are still in a sort of half-molten state, and are immediately removed into annealing ovens, which are always kept at a high temperature, so that the blocks receive no chill. The ovens are of small size, and when full are sealed up, and allowed to cool down by themselves. There are about 70 moulds upon each machine, and the hotter these are kept the better; whilst, to prevent chilling of the molten slag as it runs into the moulds, they receive a thick coating or washing of chalk or lime after each casting, the lime acting as a non-conductor as well as assisting the block more readily to drop out of the mould. Thus the casting is not allowed to remain in contact with anything which can extract its initial heat, so as to produce unequal cooling. Large quantities of these bricks or paving-blocks are used for crossings, stables, yards, and streets, possessing durability, uniformity, and good general appearance when well set. From a series of tests made against a crushing strain, some of these blocks carried a weight equal to the hardest granite.

Bottle Glass.—The next successful process for dealing with molten slag is Bashley Britten's. He converts it, by a kind of compound process, into glass for bottle-making and for many purposes where a pure white glass is not essential. The slag is taken from the blast furnace in large ladles upon wheels, in quantities of about 500 lb. In this state it can be conveyed a considerable distance to the glass works, where it is poured into a Siemens regenerative gas-furnace, known as the "continuous melting tank furnace," arranged to work with gas made by a gas producer. The material is fused and amalgamated in a melting-tank. The fluid metal, becoming fused, flows through a bridge into a secondary chamber called the gathering basin. The glass is withdrawn from this basin through a series of holes by the workmen, and fashioned into bottles, or other useful articles, in the usual way. By this arrangement the work of charging and withdrawing the liquid glass is continuous and proceeds uninterruptedly. The consumption of coal per ton of slag-glass should not exceed 10 to 12 cwt. With each charge of molten slag into the melting-tank, alkalies and sand, and colouring or decolorizing material, are added in proportion depending on the quality, colour, and composition of the glass required.

To make bottle-glass equal in quality and appearance to French champagne and claret glass about 50 per cent. of slag may be used ; for plate-glass, the same proportion, or rather less of slag ; but for glass for heavier articles, a much larger percentage can be adopted. Bottles made from slag-glass are stronger than those manufactured in the ordinary way from the usual materials, and will stand 320 to 350 lb. per sq. in. ; half-bottles (pints), 420 to 450 lb. per sq. in. Slag-glass, owing to its toughness, is especially suitable for manufacturing into tiles, cisterns, plates, slates, etc., for which glass is not now employed. The chief points of merit claimed for this process are the utilization of a waste product, economizing the heat of the molten-slag, and converting it, with additional materials, into good glass, quicker, and at less cost, than by the processes generally employed.

Slag Shingle and Sand.—(*a*) In 1871, the waste land for the deposit of slag at the Tees Iron Works being filled up, and the works of the Tees Conservancy having temporarily been brought to a standstill, it became of serious moment to know what was to be done with the slag.

The cost of cooling it, and putting it on board barges for taking out and tipping it into the sea, was so heavy that it was suggested the slag should be prepared in such a form that it could be tipped into the barges in the same way as coal is done upon the Tyne and other places. To meet these requirements several schemes were proposed and tried ; amongst the first (and only successful one) is the horizontal rotary slag-cooling table designed by Wood, and which, with little alteration, continues to work up to the present time. The machine upon which the slag falls revolves very slowly, and is about 16 ft. in diameter. The top of this table is formed by a series of slabs ; these receiving or cooling plates, or slabs, are about 2 ft. in width, each forming a segment of the circle. These plates are kept cool by having a zig-zag wrought-iron pipe cast in them, through which water circulates, being fed from a centre globe ; the water, after passing through two plates, flows into the basin under the table. These water plates are bolted down in such a way as to be able freely to expand and contract. The liquid slag, as it flows from the usual runner, spreads itself upon the moving table into a broad band of slag, varying in thickness from $\frac{1}{4}$ in. to $\frac{3}{4}$ in., depending upon the quantity and fluidity of the slag. From the point where the table receives the molten slag a distance is traversed of about 10 ft. or 12 ft., to allow the slag to consolidate ; after which, water from a jet is made to flow freely upon the surface of the hot slag until it reaches a set of scrapers, when, having become nearly cool, it is pushed off into iron waggons below. When the slag reaches the scrapers it has become somewhat brittle, and readily parts from the table, and slides off in large flat pieces. When perfectly cold it is tipped from the waggons, and falls into small-sized pieces, called "slag-shingle." The produce of this machine has found such ready sale that it has kept going almost constantly ever since it started, and about 200,000 tons have been sold, chiefly for making concrete. In place of paying 6*d.* per ton to get rid of the slag, it has realised about 1*s.* 3*d.* per ton.

The large concrete blocks, each weighing about 230 tons, constructed by Fowler, for dropping into the sea to form the head of the Tees breakwater, are chiefly composed of this material, and several heavy foundations for engines, drainage work, building, etc., in the district, have been executed with it.

(*b*) The next great step in advance, and which laid the foundation for several processes hereinafter mentioned, was the reduction of the molten slag, as it flows from the surface, into a soft spongy kind of sand, by a machine known as Wood's slag-sand machine. In principle it is the reverse of the slag-shingle machine, inasmuch as, instead of the wheel being horizontal and the slag running upon a dry table, the slag flows into a wheel placed upon its edge, and falls into a bath of water, varying in depth from 18 to 24 in. The wheel or drum is of wrought iron, and about 14 ft. in diameter. It is fixed and carried on curved arms. The arms are curved to allow, in the first place, the slag runner or spout to enter the wheel; and secondly, to make room for the sand-receiving spout on the opposite side at the top. The wheel makes about five revolutions per minute, and the water contained inside is partly carried up by the elevators, and in falling causes a constant rush of water to the bottom. Perforated screens, or elevators, are arranged to screen the slag from the water, and lift it to the top of the machine, where it drops upon the sand-receiving spout, and thence slides in a constant stream into wooden waggons. The spout is also perforated, to allow any water which has been carried over with the sand to return into the machine. The perforated buckets have another important function to perform, viz. that of agitating the water. The water, in rushing to the bottom, meeting these obstructions, rolls over in a violent manner, and into this agitated water the liquid slag flows just as it comes from the furnace. The united action of the agitated water and the formation of steam, scatters, as it were, the molten slag in the water into the material called slag-sand. The wear and tear of this machine is very light, there being no working parts coming in contact with the sand or the heat. The heat, being taken up by the water, is thrown off in the shape of steam, which comes away in large volumes. Grey slag takes up about 20 per cent. of its own weight in water. The total cost of this sand in railway trucks is about 6*d.* per ton.

On the Continent a kind of slag-sand has been made—prior to the adoption of the process just mentioned—by running the slag into tanks full of water, and elevating the sand by chain buckets into waggons; but the apparatus is very imperfect, and will only work slag made from forge iron, known as black slag.

The application of slag-sand, in so cheap a form, to the useful arts, naturally followed the production, and after numerous experiments, extending over many months, it was decided to establish separate works in close proximity to the furnaces, where, under Wood's own direction, various processes could be developed. In Georgemarienhutte, in Hanover, under the direction of Luurnan, a process of brickmaking was initiated a few months previously.

Prussian Method.—(*c*) The high furnaces are provided with a continual overflow for the slag, which runs through a narrow gutter formed in the sand into a shallow pit, through which a small stream of water is kept running. By this chilling process the slag assumes the form of a fine gravel. An endless chain at once lifts the slag out of the pit and loads it upon cars. By grinding this material fine in a cement-mill it is formed into an excellent sharp building-sand ; the great bulk of it, however, is used, without further reducing its grain, for making bricks.

For this purpose it is mixed with one half of its bulk of mortar in a trough in which three shafts provided with long blades are revolving. It is then shovelled into the brick-machines, each of which turns out about twenty-five bricks a minute. These bricks are piled up in the open air for drying, and are ready for use after about six weeks. They continue to harden on exposure to the air, and are said to possess greater strength than ordinary burnt bricks. They are extensively used for all kinds of buildings, their light-grey colour producing a very pleasing effect, and the roughness of their surface fitting them particularly well for retaining a coating of mortar. They cannot be used, however, for foundation walls, as by the absorption of moisture their cohesiveness is impaired.

(*d*) The remarkable setting properties of slag in a state of subdivision has attracted the attention of scientific men for years, and many schemes for producing artificial stone, cement, etc., have been tried ; but, in consequence chiefly of the cost of disintegration, no results were obtained with commercial success.

John Gjers, of Middlesbrough, produced a coarse kind of slag-sand, which, after grinding under edge-runners, was used extensively for some little time, upon the pig-beds ; but it had to be abandoned, because it consolidated too much, causing violent explosions (technically termed "boils"), from the steam from the damp sand being unable to escape when the metal was run from the furnace in pigs.

Cement.—(*a*) The three most important component parts of slag are silica, alumina, and lime, forming, as they do, about 90 per cent. of the whole. The latter of these, however, chiefly exist as silicates ; if to these, caustic lime be added, they are acted upon, water of combination or crystallisation being taken up ; and if the material be kept damp and exposed to the air, hardening or induration is carried on for months.

If caustic lime be added to slags poor in lime, so as to bring this element up to 55 or 60 per cent., it will be seen at once how closely it will resemble the analysis of Portland cement, the composition of which is as follows :—Lime, 60 per cent. ; silica, 24 ; alumina, 8 ; iron oxide, 4. German Portland cement is sometimes made with as low as 55 per cent of lime, whilst Roman cement has often only 50 per cent. of lime ; but these will generally be found to contain oxides of iron in an increased proportion.

The remarkable hardening effect of oxides of iron in conjunction with lime, silica, and alumina, is well known, and is well exemplified in the Italian puzzolanas, where, in several of the best qualities, the lime is actually as low as 8 per cent., whilst the oxides of iron run up to 12 or 15 per cent. The hardening effects of iron oxides induced Wood, prior to the development of the slag industries, to employ the dust from the iron-stone clamps in place of sand when making concrete for heavy foundations, and the setting properties and strength of this combination have upon examination been fully confirmed. Again, having to erect a row of columns for a large roof upon the bed of an old iron-stone clamp, the floor of which had been accumulating for several years, it was found to be so extremely hard that Wood simply levelled the bed down, and set the columns directly upon it. These, after many years, show not the slightest signs of settlement, although the ground underneath had been made up from ships' ballast.

It appears an absolute necessity for obtaining good results that the ferruginous material should be calcined or roasted, the effect of which is to drive off the carbonic acid and water; the reabsorption of the water, which unites in chemical combination with the material, afterwards assists in hardening.

(*b*) The word cement has sometimes been objected to in connection with this material, because it is generally manufactured in a wet state, and must be used within a few hours of its being made. Upon this point Wood expresses no opinion, simply mentioning the fact that, in point of strength, he finds little difference whether the materials are ground together in a dry or in a wet state. The cost of production, however, is as nearly as possible 4 to 1 in favour of the wet state. It is made by grinding under edge-runners for about 1 hour (the finer the better), 70 per cent. of slag-sand, 15 of common lime, and 15 of iron oxides, calcined iron-stone, or spent pyrites. Following is an analysis of this cement:—

	Per cent.
Lime	22·90
Silica	21·60
Alumina	19·85
Iron protoxide	4·00
Manganese protoxide	0·21
Iron peroxide	8·80
Magnesia	4·36
Potash	0·50
Soda	0·32
Suphur	1·19
Sulphuric acid	1·54
Phosphoric acid	0·02
Carbonic acid	3·00
Total water	12·00
	100·29
Less oxygen of the lime combined with sulphur	0·59
	99·70

Upon comparing this analysis with that of Portland cement and the puzzolanas already given, it will be seen that the various hardening ingredients exist in all.

The large quantity of water held in suspension in the slag-sand is quite sufficient to make the mass in the mill into a semi-fluid state, but this water is mostly taken up in setting, as water of crystallisation. It is therefore necessary that the cement should be used before setting takes place. This cement is usually employed for making concrete, by mixing one part of the cement to five of slag-shingle. The shingle is made by the slag-shingle machine before described.

The shingle, before being used, is well wetted; and when the concrete is put into place, it is beaten lightly down in a soft state, until the water and cement begin to rise on the top; two days afterwards it has become sufficiently set to allow of the building-boards being taken down, and at the end of a week it will be fairly hard, and will go on hardening for months. It is perfectly hydraulic, and will harden under water. It will be seen by this that it requires a longer time to set than Portland cement, and is perhaps not quite so hard; but there is a remarkable toughness, which has surprised all those who have used it, and this toughness makes it valuable for heavy machinery foundations, etc.

Whilst the underground walls of the Slag Works referred to above were being executed they were twice immersed, through exceedingly high tides, with the result that this part of the building is the hardest of all; and to give an idea of the strength, Wood mentions that when it was necessary to cut two openings at different points through the basement walls, 3½ ft. wide and 6 ft. high, this employed two good workmen, with steel bars and sledge hammers, at least four days for each doorway. He knows of no material at a similar cost which can compete with it, and he is satisfied that it has only to be widely known to be more extensively used. Personally, where time can be given, he employs nothing else for all heavy foundations for rolling machinery, for which purposes, as a conglomerate or monolithic mass, it is peculiarly adapted. Slags from the furnace making Bessemer iron are better adapted for this cement even than those from the Cleveland ores.

Mention has been made of the necessity of keeping the products from slag-sand in a damp state for a length of time after manufacture in order to give them time to harden, or, in other words, to allow the material to absorb or take up as much water as will chemically combine with the lime, silica, and alumina; but whether this water becomes water of crystallisation, or water of hydration, or a combination of both, is not at all certain. Wood is, however, strongly impressed with the idea that water in a fixed state, more particularly in a compound state, plays by far a more important part in the setting of cements than is generally supposed; that the presence of water in a chemically combined state forms as much a constituent part of cement as does the lime, silica, and alumina, seems certain from the results of the analysis shown further on. For instance, if Portland cement be heated to redness, so as to evaporate the fixed water, the cement loses at once its strength, and becomes rotten. Again, with gypsum, where the water of crystallisation amounts to more than one-fifth of its bulk; if this is driven off at a red heat we have little better than a powder left. And it seems clear that the quicker this crystallisation takes place, the quicker is the setting; and, on the contrary, as in the slag cements and the brick, the slower the water is in becoming fixed, the slower is the hardening; thus showing the necessity of keeping them damp during the process.

(*c*) Ransome, the well-known inventor of artificial stone, has recently taken out a patent for mixing the slag-sand in its wet state with chalk, and then burning the whole together in a cement kiln into clinker, after which he grinds it down in the same way as Portland cement. The results given are remarkable, exceeding Portland cement in strength by nearly 30 per cent.

(*d*) Reid made some experiments on the application of slag to the manufacture of Portland cement, and could not get very satisfactory results; but that was before Wood's granulated slag was to be had. He found the greatest difficulty with the sulphur. He got in his slag about 1¼ per cent. of calcium sulphide, which would amount to about 2·84 per cent. of lime sulphide, in the cement when finished, an amount which made the cement very unreliable. He found also that, in working up the slag with the lime, it was very difficult to incorporate the two thoroughly; but it was very possible that Wood's granulated slag, which was very finely divided, might be more easily mixed with lime. The amount of sulphur usually contained in Portland cement, according to Grant, is nearly 2 per cent. If you were to make cement from slag already containing 12 per cent. of sulphur, you would get 4 per cent. of lime sulphate in it, which would render it unreliable. This process was patented by Bodmer in 1866; the specification stated that the invention consisted in the manufacture of a cement by mixing together slag cinder or scoria, whether naturally or artificially produced from furnaces, with a certain proportion of lime or calcareous matter, and with or without alumina. Egleston has referred to blast-furnace slags being used for various things, and amongst others for the manufacture of cements. He said that the possibility of having them in the form of granulated slag reduced the price of the pulverised material to such a figure that, in certain parts of Germany, an artificial cement equal in every respect to the best Portland was manufactured at a large profit.

Mortar.—Mortar for building purposes is simply made by grinding the slag-sand with about 6 per cent. of slaked lime in an ordinary mortar-mill, and (if ground fine) it makes a far better mortar than is generally employed by builders. There was at one time a very large demand for this material in Middlesbrough. There is only one objection made to it, viz. that it sets too quickly. Mortar supplied on the Saturday, left unused, would be worthless on the Monday. As with the other slag products, its remarkable strength and cheapness combined make it much liked by those who, in close proximity to the works, can obtain it freshly made.

Bricks.—A most important production, and the one which consumes by far the greatest quantity of slag, is that of concrete-bricks, known in the market as slag-bricks. These are made from the sand produced by the slag-sand machine before described. The sand is dropped from the railway waggons into hoppers, or depôts, at the works, whence it is filled into large barrows, taken up a hoist to the top of the building, and tipped into a hopper, which supplies a measuring apparatus. Here it is mixed with a certain quantity of selenitic lime (General Scott's patent), with an addition of iron oxides; it then passes into the brick-press hereinafter to be described. The bricks are taken off the presses by girls, placed upon spring-barrows carrying 50 bricks each, and removed to air-hardening sheds; here they remain a week or 10 days, after which they are stacked in the air to further harden, and at the expiration of five or six weeks they are ready for the market. Here is the curious anomaly of bricks being made without burning, and of a wet season being favourable to the hardening process. The bricks thus produced are very tough; they do not split when a nail is driven into them, and are easily cut; they do not break in transit, and the frost has no effect upon them.

The preparation of this selenitic lime forms a necessary branch of the business. It is made in the following manner:—

80 per cent. of unslaked common lime.

10 per cent. of raw gypsum.

10 per cent. of iron oxides calcined.

These are all ground together, under edge-runners, into a fine dry powder. The composition is then passed through a fine sieve, 24 meshes to the inch, and is ready for the brick-press. To each 1,000 of bricks, 6 cwt. of this lime is used; no water is added, sufficient being held in suspension in the slag-sand to thoroughly moisten the lime; in fact, it is no uncommon thing to find flowing from the brick-press a stream of water which has been squeezed out of the sand. The loss of bricks in manufacture is very small; in fact, after the bricks are once upon the barrows, the waste is not more than 1½ per cent. The weight of these bricks is about 30 per cent. lighter than ordinary red ones—9 in. by 4½ in. by 2½ in.—weighing only 2¼ tons per 1,000.

As before mentioned, the lime used for making bricks is selenitized, the following being the analysis of the raw gypsum employed in the process:—

	Per cent.	
Sulphuric acid .	46·18	Lime sulphate
Lime	32·32	
Silica	0·35	
Water at 100 per cent. . . .	Nil	
Ditto given off at red heat, being water of crystallisation . .	21·00	
	99·85	

The process of brick-making, as now carried on, is extremely simple and inexpensive; but it was here that the greatest difficulties were met with. There was no machinery to be purchased that could work the slag-sand into bricks in the state in which it arrived from the blast furnaces. In the earlier attempts, the sand had to be prepared in a fine state, the result being a superior class of bricks, but at a cost so great as to exclude them from the market. Wood had therefore to design and construct brick-presses and other machinery that could work the sand, as it came from the slag-sand machines, directly into bricks.

In designing the press, the following

points had to be kept in view, viz.: unusual depth of brick moulds, as the sand (being spongy) is exceedingly compressible; great pressure, in order to consolidate the slag; as well as great care in mixing the lime in fixed proportions to the sand—too much lime tending to burst the bricks, whilst too little seriously affects the hardening.

Artificial Stone.—(*a*) One other manufacture from slag is that of artificial stone. It is moulded into chimney-pieces, window-heads and sills, balustrading, wall coping, and other ornamental work for builders, as well as for paving for footpaths, stables, etc. The stone is composed of 2½ parts finely-pulverised slag, and 2½ of ground firebrick, to one of Portland cement; the mixture is run into moulds, and sets quickly, the articles being ready for the market in 5 or 6 days.

(*b*) A sort of concrete brick has been made also from hematite Bessemer slag. These bricks have been made by a process differing entirely from the system adopted by Wood at Middlesbrough. The slag employed is pulverised from the cold solid mass under heavy edge-runners, which crush the material into fine dusty shingle; it is then lifted by elevators into French burr-stones, and ground down as fine as sand. From the stones it passes through a worm conveyer to a brick-press, during which about 25 per cent. of common river-sand is added, with sufficient water to thoroughly damp it, without any addition of lime; again showing, in a remarkable degree, the extraordinary setting nature of the slag after the chemical combination with the water and exposure to the air have taken place. These bricks are taken from the press and placed under cover for a few days, when they are put out in the open air to harden. They are of excellent shape, grey colour, and become exceedingly hard. Large quantities have been employed in building, and appear to be standing remarkably well. The cost, however, is very heavy, owing to the difficulty of preparing the slag and the wear and tear of the machinery; the excessive weight also precluding the sale at any great distance from the works. The large amount of lime, combined with the silica and alumina in the Bessemer slag, quite accounts for the setting properties. The bricks continue to harden for years, and appear to arrive at a kind of crystalline fracture, which damp greatly accelerates.

Manure.—(*a*) A material containing so much lime, silica, alumina, sulphur, and magnesia, in a condition like the white soft slag-sand, suggested its application as a fertilizer for some kinds of land. Some years ago it was brought before the Royal Agricultural Society, and Dr. Voelcker reported that the result of his examination showed that it might be usefully employed upon moorland and peaty soils as a cheap and effective substitute for lime. Since this report was made, many hundreds of tons have been sold for this purpose, and although there was only 32 per cent. of lime in the slag supplied, the results have been very satisfactory, particularly on land growing potatoes. Had it been Bessemer slag, containing 40 to 50 per cent. of lime, there cannot be a doubt that the results would have been still more satisfactory; and Wood feels sure that it must in some localities find a large outlet for this purpose.

(*b*) The successful attempts made in recent years to remove the phosphorus from iron in the course of manufacture by the basic process have attracted the attention of chemists to the possibility of recovering the valuable manure phosphoric acid from the slag. A patent was obtained by Thomas and Twynam for the manufacture of phosphoric acid and phosphates from slag, especially adapted to their recovery from slags produced in the basic Bessemer and Siemens processes. The slag is first finely ground, and the particles of iron are picked out by means of magnets; it is then treated with sufficient hydrochloric acid, either in aqueous solution or in vapour to dissolve out the phosphoric acid, and part of the iron oxides. The powdered slag may first be roasted in a calciner to oxidize the ferrous oxide. If sufficient ferric acid be not present in the solution to combine with all the phosphoric acid, it will be necessary either to add some ferric oxide or puddlers' slag (which should perferably have been first roasted), or to oxidize any ferrous oxide present, either by chlorine gas or by the addition of manganese binoxide (in which latter case there must be sufficient free acid in the solution to cause the decomposition of the manganese binoxide and set free chlorine), or the ferrous oxide may be oxidized by other well-known means. The solution is then run off from any insoluble residue, and sufficient lime or (preferably) chalk is added to cause precipitation of ferric phosphate (magnesian limestone may be used in place of ordinary limestone for this purpose, the magnesia dissolved being afterwards precipitated by lime). The precipitation of the ferric phosphate may be effected in the cold, keeping the solution well agitated; but a gentle heat causes the precipitate to settle down better. When the precipitation is complete the ferric phosphate is separated from the solution by filtration, and washed to free it from calcic chloride. The precipitate is then dried, so as to drive off all its water, and digested with a considerable excess of sulphuric acid, so as to decompose it into phosphoric acid and iron sulphate, which latter is insoluble in the excess of sulphuric acid employed. Ordinary chamber acid is able to effect this decomposition, but a stronger acid, such as is obtained when using a Glover tower, is better adapted for the purpose. The ferric phosphate should be kept well agitated in the liquid, which may be gently heated to facilitate the decomposition. When the ferric phosphate is considered to be completely decomposed the insoluble ferric sulphate is separated from the solution containing the phosphoric acid and excess of sulphuric acid by means of a filter-press. The filtrate will be found to contain nearly all the phosphoric acid in a free state, together with the excess of sulphuric acid, from which it may be separated by the aid of heat; the sulphuric acid being driven off and condensed, leaving the phosphoric acid practically pure, or the solution containing the mixed acids may be used in place of ordinary sulphuric acid for making super-phosphate of lime. The iron sulphate precipitate after being washed with sulphuric acid may be decomposed by heat into ferric oxide and fuming sulphuric acid, or it may be mixed with salt and heated to form sodic sulphate. In some cases, when there is no lime in the slag employed (as when treating puddlers' cinder), the phosphoric acid is thrown down as a mixed ferrous and ferric phosphate by means of lime without previous oxidation, and is then dried and treated in the same way as ferric phosphate.

Casting-Beds.—In the Siegen district, Belgium, granulated slag is used for casting-beds, and gives clean pigs, preferred by the puddlers even to those cast in iron moulds.

Cleveland Slag Works.—In works where so many special manufactures have been developed the arrangement of the building—the design, position, and working of the machinery at present used—must necessarily have been arrived at only by hard-earned experience. The building is constructed of slag-cement concrete throughout; the main building has four floors, the size of which is 46 ft. by 33 ft., whilst the slag-sand stores, gantry, engine-house, lime-house, etc., occupy 97 ft. by 47 ft. The slag-sand is brought from the blast furnaces in large wooden railway trucks, holding between 7 and 8 tons each, and is run up an incline by the locomotive into a gantry. The bottom doors of the trucks are opened, and the slag-sand is dropped or emptied into hoppers below. These hoppers are capable of holding about 600 tons of slag-sand, or storage enough for one week for three machines, and should be kept constantly filled. From these hoppers it is drawn into large wheel-barrows, and is taken up by a double-acting hoist to the top of the building. This hoist is driven from the main shafting in the mill, and is worked by two belts, one crossed, the other open, for the purpose of reversing the cages. The cages can be made to stop themselves at any floor, and have a self-acting brake to prevent any movement of the cages after the straps are thrown off, the action being most simple and effectual.

The sand-barrows are taken from the hoist at the top of the building, through a passage, and tipped into the hopper which supplies the brick-presses. Selenitic lime is fed into a small hopper, by hand, from a chamber or floor above. At the bottom of these sand and lime hoppers are the measuring apparatus, which accurately measure both the lime and the sand in the proportions necessary. From the measuring drums the material falls upon sifting and mixing apparatus, from which it falls through the floor into the brick-press. This press has been designed especially for the purpose, and has many new points. It is of immense strength. The pressure is obtained by two cast-steel cams, which are fixed upon a forged steel shaft 7¼ in. in diameter; this shaft, resting on bearings between two strong frames, is put in motion by very powerful double-geared spur-wheels, the first motion shaft having a heavy fly-wheel upon it to steady and equalise the pull upon the strap. The pressure cams act against rollers fixed upon two steel cylinders or rams. These rams transmit the pressure to the moulds under the table. The table is circular, and contains six pairs of moulds, so that four bricks are pressed at one time, the table remaining stationary during the operation. At the same time the bricks are being pressed two other pairs of moulds are being filled up with material, whilst the other two pairs are delivering up the four bricks already pressed at the previous revolution of the cam shaft. The bricks are pushed out of the mould by smaller pistons, which are acted upon by separate cams. The moulds are lined with changeable steel plates $\frac{3}{16}$ in. thick, and the sand and lime are fed into two pug-mills. These pug-mills are fitted with six knives each, so as the more thoroughly to mix and chop the spongy slag with the lime. The table is shifted round by a kind of ratchet motion. Immediately above the pressure-cylinders are two pressure-stops, which are held down by the heavy-weighted levers. These levers, therefore, receive the whole pressure put upon the bricks; and in case there should be too much sand getting into the moulds, they simply lift up and relieve the strain. The weights can be weighted at option, and thus form an exact gauge of the pressure upon the bricks. The moulds are generally filled so as just to lift the levers in ordinary work. The filling is easily regulated by the set of the knives on the pug-shafts, which press the material into the mould, and one side of the pug-mill cylinder is made to open, so that the knives are accessible at any moment.

The pug-mills are filled by means of measuring and mixing apparatus placed on the floor immediately above the brick-press. The mixing and measuring apparatus is very simple and efficient, and works without trouble. The slag-sand is tipped into a hopper by large barrows, which are lifted up by a hoist. At the bottom of this hopper there is a revolving cylinder, with ribs cast upon it, which, revolving under the hopper, carries a certain thickness of sand, previously regulated to the requirements of the press. The slag then falls upon a sieve, which separates any large pieces in a solid state, and at the same time allows the sand to fall through the sieve like a shower. The lime is fed into a separate hopper, and is regulated by a feed-roller of smaller size; it passes down a shoot, which forms part of the slag-sand sieve, where it meets the shower of sand, falling together with it—thus getting thoroughly mixed.

On the right side of the slag gantry and hoppers is the mill for preparing the selenitic lime. The lime, after being ground under edge-runners, is passed through a sifting apparatus, the wire of which has 24 meshes to the inch; it then falls into a hopper, is taken by barrows through a passage to the hoist, and lifted to the lime chamber before mentioned. In a line with this mill, and parallel with the slag gantry, are the stores for the lime, gypsum, and iron oxide; whilst behind the lime-house are the engine and boiler.

The hardening-sheds are three in number, and should be each about 100 ft. by 40 ft. The floor must be perfectly smooth and level, as an uneven floor spoils the bricks. The sheds should have plenty of ventilation, and require to be cool in summer. Great care is necessary in stacking these bricks; as they come off the barrows, they are placed on edge quite close together, and stacked six in height, and when once here in position there is little or no loss afterwards.

Slag-Wool (*Mineral Wool, or Silicate Cotton.*)—(*a*) The following is extracted from a lecture delivered by Fredk. M. H. Jones.

When first commencing the manufacture of slag-wool in this country, the material was blown direct from the iron furnaces, that is to say, we tapped the iron furnace at the reverse side of that where the iron issues to be converted into pig-iron. The stream of slag was blown upon by a steam blast through a jet, and the fibres were blown into a large receiving chamber where a portion was bagged up and sent off to the market, the balance being converted into sheets or slabs.

The output by this means was somewhat limited, as space in the immediate vicinity of the iron furnaces was valuable, and as the demand for the material increased, we had to take a leaf out of the book of our smart American cousins, in whose country the market is much larger, and we had to forsake the large iron furnaces for the Cupola system. This system consists of feeding a cupola furnace with minerals from the top; the fuel employed being washed coke. The coke and slag are thrown into this cupola in alternate layers, with a certain quantity of other minerals which assist in bleaching the fibre, and cause a fluidity of the materials. A blast is required in order to secure the necessary heat to cause the mass to melt. As the fluid stream issues forth from a tap hole at the bottom of the cupola, a jet of steam is brought to bear on the stream of molten mineral, and is blown into a receiving chamber, in exactly the same manner as I have already referred to. I should here mention that iron melts at a temperature of 1992° F., but slag requires a considerably greater heat, about 2500°, to enable it to fluidify. The material is to all practical extent and purposes acid proof—that is to say, it can only be affected by very strong chemicals, not met with in a general way. The fibre is practically everlasting; having passed through a furnace, any trace of organic matter which it contains has been quite destroyed.

Before proceeding to dilate on the numerous uses to which slag-wool is put, let me inquire into its non-conducting properties. In the first place I may mention that 1 cubic foot of slag weighs 150 lb. avor., but when this single cubic foot of slag is converted into slag-wool fibres, it has always been held to measure as much as 12 cubic feet at least, so you will see there is held in suspense fully 11 cub. ft. of air to the one cub. ft. of slag. This clearly shows the remarkable air-harbouring value of the material. To clearly demonstrate my meaning *here is* a little block of slag, weighing precisely 8 lb., and here is the same article blown into 8 lb. of slag-wool. Well, no one will say that this lump of slag is a non-conductor. Why? Because it is a dense, solid body. Equally, you will all agree that slag-wool is the best of non-conductors. Why? Because it contains 11 parts of confined air-cells, to 1 part of stony fibre. In fact it is a characteristic of slag-wool that the fine glassy fibres, which compose it, lie transversely and interlace each other, forming myriads of tiny air-cells ; and it is a scientific fact that confined air has no rival as a non-conductor.

To proceed with the advantageous uses of slag-wool it may be mentioned that the material is largely employed in connection with engineering and allied trades for a variety of purposes, such as :—

Covering boilers, steampipes, cylinders, etc., in order to avoid loss of heat through radiation and consequent loss of fuel.

Lining bulkheads uptakes, refrigerated holds, etc., on board ship ; and for lining refrigerator cars and locomotive boilers on railways.

Lining gas cooking stoves, in order to economise the consumption of gas.

Lining incubators.

Covering water mains and other pipes to render them proof against severe frost, etc.

Frostproofing.—The protection of exposed cisterns in London used to necessitate the use of considerable quantities of non-conducting lining, but the comparative mildness of the climate now, combined with the modern regulations concerning the position of these vessels, has greatly reduced the demand for any sort of anti-thermal lining.

Heatproofing.—Let us consider this as, perhaps, next in importance to frostproofing. In the United States of America, where extremes of climate are more prevalent than in our own, there is greater demand for anti-thermal lining for buildings of every description. In those States, long periods in the summer with the mercury averaging 90 degrees Fahr. are experienced, whilst in the winter, they have long spells with the thermometer registering several degrees below zero. This is where slag-wool, as a non-conducting lining for roofs, is highly appreciated.

Notwithstanding the temperate nature of our own climate in recent years, I have had many testimonials from the owners of shooting boxes, etc., who have experienced the advantages of slag-wool as a medium for keeping buildings warm in winter and cool in summer. The material has been found of great use in lining the roofs of bedrooms in attics and nurseries, as well as of factories. Owners of the latter testify to the conditions under which workmen have been enabled to carry out their daily work without being affected by extremes of temperature, and this is of greater importance than at first sight might appear. No one knows better than a works manager to how great an extent a spell of tropical weather in this country affects the turn-out of manufactures, but not all know how the loss may be greatly diminished by a slight expenditure on, say a one-inch lining of slag-wool.

The advantages of slag-wool as an anti-thermal lining for buildings has, perhaps, been more appreciated in our Colonies and abroad than in our own country. This is, in a great part, due to the fact that in the Colonies, corrugated iron and similar structures are more in vogue, and everybody knows that there is no more pernicious material for absorbing heat or cold than iron, it being an ideal conductor. Ordinary roofing felt is frequently employed for lining the inside of such structures, but I suggest that the thinness of this material renders it practically useless for the purpose. I can only assume that this practice is due to misunderstanding.

Hair felt is admittedly a very good non-conductor, and really suitable for the purpose, but for its objectionable habit of encouraging moths and other vermin. Slag-wool, being an inorganic substance, does not possess this serious disadvantage, and it also lends itself to being employed at greater thicknesses than felt, at a much less cost.

Whilst on the subject of the prevention of the radiation of heat. Slag-wool has been used for lining walls of rooms which back on to fireplaces in adjoining houses. The heat, radiating through the walls, injures pictures, and the passage of heat often causes other inconveniences in adjoining rooms. There are numerous other uses to which silicate cotton may be put in buildings as a preventative against conduction of heat; for instance, as a lining for hot air ducts passing along passages, covering hot water pipes, etc., but such uses readily suggest themselves to practical minds.

Cold Storage Insulation.—Slag-wool, as a lining for refrigerating chambers in cold storage structures, illustrates the value of it for arresting the passage of heat. The cold storage movement has been booming in this country for some years past, and practically every town in the kingdom has its cold air store for the accommodation of perishable products. The cold which is necessary for the preservation of the goods is produced, of course, by means of refrigerating machinery, but were the surrounding walls of the chambers not well insulated, the warmer outside air would be constantly finding its way into the chambers and nullifying the work of the machines. For this reason, an efficient non-conducting lining is as essential for the economical working of the establishment as good refrigerating machinery. I can safely say that 90 per cent. of the principal cold air stores in this country are lined with slag-wool.

Soundproofing.—So far as its application to buildings is concerned, I class the subject of the prevention of the passage of sound, or the muffling of sound, as the most important. Although the success which has attended the use of silicate cotton and the extent of its employment are very gratifying, I must frankly say that there is still abundance of scope for architects and builders to interest themselves more than they do in the subject of sound-deadening. The general adoption of thick concrete floors in London buildings may have, to a great extent, spared architects the necessity of considering this matter. There is no doubt that such floors muffle sound to a considerable extent by reason of their thickness, but the fact is, the great cost of such floors render the additional use of soundproof lining out of the question.

Sound is carried by walls from one floor to another, in almost as great a ratio as through floors, and the study of how to soundproof a room requires some consideration, much depending on the different circumstances of the structure, and as to whether soundproofing or merely sound-deadening is required. To me, there is a distinct difference between "sound-deadening" and "soundproofing." Ordinary mortar pugging, which is, perhaps, employed to a greater extent in better class buildings in Scotland and the North of England than in the South, serves the purpose of sound-deadening fairly well, but it possesses certain apparent drawbacks in being applied in a wet state. Slag-wool is always applied dry for this purpose, and the possibility of dry rot resulting from its use is, therefore, absent. Slag-wool also possesses the power of breaking up and absorbing sound-waves in a great degree, and it, at the same time, meets the other requirements of durability, reasonable cost, and hygienic properties.

In the case of sound-deadening a partition by packing loose slag-wool between the studding, strips of hair felt may be used with advantage to line the studs on the outside. The use of such strips of hair felt on the top of joists is, however, of practically no value, as the weight of the floorboarding crushes it to such an extent as to cause it to lose its resiliency, and its sound-wave absorbing properties.

Everybody knows how the study of sound-preventing has been neglected in the past in the construction of that comparatively modern institution, the dwelling flat. This neglect is in great degree the cause of the aversion with which many people view such buildings. There is little, if any, excuse for the neglect I refer to. In these days of advanced civilisation, that which some years ago was considered a luxury is considered nowadays as an actual necessity, and it seems strange that so little advancement has been made in soundproofing flats. The trifling cost which would attend the free use of slag wool for the purpose would prove a good investment to the landlord.

Where the value of slag-wool as a soundproofing medium appears to have been most highly appreciated is in colleges, music schools, dancing academies, concert halls and hospitals.

In many of those places in London alone silicate cotton has given most meritorious results. For instance, the divisional wall between Queen's Hall and St. George's Hall, Langham Place; the Royal College of Music, Kensington Gore; Cavendish Rooms, Mortimer Street; Royal Organ School, Princes Street, W., etc.

Loose slag-wool is generally used for muffling sound between floors by laying rough sound-boarding, resting on fillets fixed to sides of joists, and about 1½ in. from top of joists. The space between the sound-boarding and the top of joists is packed firmly at hand pressure with the loose material, and then the floor-boarding laid on the top. Whilst this system of deadening sound possesses many advantages over others, a certain percentage of sound must necessarily be conveyed by means of the wooden joists themselves. A complete insulation of sound can, however, be secured by the adoption of a sheet form of silicate cotton, for instance, combined slag wool and plaster slabs. These slabs consist of sheets of plaster with an internal layer of 20-gauge galvanised wire netting, and padded with a one-inch thickness of silicate cotton, held in position and secured by means of another sheet of wire netting and soft wire. These slabs are secured to timber joists or uprights by means of 3-in. nails, and the keyed face of plaster slab is finished off in the same manner as an ordinary fibrous plaster slab may be treated. Nothing extraordinary in the way of timbering is required, ordinary joists or uprights fixed at the usual distances apart sufficing.

The application of slag-wool in a room in no way injures the acoustic properties of the space, in fact, the very reverse effect is experienced.

One cannot help sometimes feeling amazed at the assurance of some manufacturers who claim sound-deadening properties for structural materials in buildings which have nothing of an air-harbouring nature in their construction, in fact, any cavities which would hold still air in suspension would be a detriment to the structure, inasmuch as it would weaken it. Such claims are generally a poor compliment to the intelligence of the individuals to whom they are supposed to appeal. It is the air-harbouring propensities of slag-wool which endow the accumulation of its fibres with a sound-deadening virtue, which is not to be found to the same extent in any other building material whatever. In closing the subject of sound-deadening, I might here relate a rather funny incident which occurred some years ago. An architect specified slag-wool to be used for pugging floors to deaden sound. We knew approximately the quantity which would be needed from the figures of the superficial area in our possession. In due course the builder sent along an order for one cwt. of loose silicate cotton to be delivered on the job. I subsequently called to ascertain when the balance might be required, but the builder's representative informed me that the bag sent would be quite sufficient. My curiosity was aroused, and the gentleman frankly showed me the process of application. Guess my surprise when I found a man crumbling the fibre between his hands, and sprinkling it on the top of the joists like powder.

Fireproofing.—If I treated the subject in anything like the manner and at the length which it deserves, it would be taking too much time. I therefore confine myself very briefly to this part of my paper. I have already explained to you that slag, of which slag-wool is practically constituted, can only be affected by heat at a temperature of about 2500°, which is about 600° in excess of that at which iron melts. This fact, alone, explains to you at once the great fire-resisting power of slag-wool. Were slag-wool capable of being converted into a structural material the field for utilising it would practically be unlimited, and concrete, which is the predominant fireproofing agent nowadays, would fall into comparative disuse.

We have, therefore, to content ourselves by making use of slag-wool in the various slab and sheet forms for rendering roofs, floors and partitions fireproof, and also as a non-conducting protection for steel and iron girders. Rather an unfortunate idea prevades the building trades that a timber floor, rendered fireproof by means of one of the slab forms of slag-wool which I have before me, is too expensive as compared with concrete and iron, but such is really not the case. A floor fireproofed by means of slag-wool renders the joists, if perchance they happen to be iron or steel, proof against the effects of fire, that is to say, when the underside of floor is subjected to extremes of heat, in the case of a conflagration, the heat cannot possibly transmit itself through slag-wool and cause the dangerous and fatal tendency of the structure to warp and splinter.

Apart from the economy that may be effected in the construction of fireproof buildings, such as flats (and might I here mention country mansions, in which there has been quite an epidemic of fires lately), a soundproof building is at the same time secured, and in these days, when cheap luxuries are so much sought after, this advantage is of great importance.

The great fires in St. Mary Axe and Cripplegate a few years ago clearly demonstrated what damage can be done by the twisting and contortion of the girders influenced by excessive heat. As a matter of fact, some classes of wood are much more fire-resisting than iron or steel. The fire causes a charring of the beams, or, in other words, envelopes the body of the beams with a non-conducting lining of charcoal. Therefore oxygen cannot penetrate, and without oxygen we cannot have combustion.

(*b*) Of late years iron-founders have made so many improvements in the extraction of iron from the ore that the slag has lost some of its value for mineral wool, and the wool is now made from the slag heaps of former years with better results. The slag, when delivered at the works, is broken into 4 lb. to 8 lb. lumps, and is then elevated to a platform by an endless belt carrying buckets. From there it is fed into the top of a cupola with about 12 per cent. of limestone and 8 per cent. of sandstone. The limestone is added to give the wool its white colour, and the sandstone helps to make it light and fluffy, as the slag by itself is glassy and rather heavy. It takes about two tons of coal and over a ton of coke as fuel to every ten tons of the rock mixture. The three heating cupolas are about 4 ft. in diameter inside, and nearly 7 ft. outside, as they are built of heavy iron and lined with firebrick. They are from 12 ft. to 18 ft. high. An air pipe about 10 in. in diameter encircles the base of each cupola, from which tuyères about 3 in. in diameter lead into the base of the cupola.

A layer of wood is followed by a layer of coal and coke, then a layer of the rock mixture. More coal and another layer of rock having been placed in the cupola, the fire is started, and an air blast with a pressure of from 3 lb. to 5 lb. per inch is forced through this mass, soon heating and fusing it. When it is in this state a small opening is made at the base of the cupola, and a stream of the fluid mass, as thick as the stem of a clay pipe, is allowed to run out. A steam-pipe with steam of 90 lb. has a suitable opening about a foot below the base of the cupola, and a few inches from the stream of melted rock. A valve being opened, steam rushes out of the pipe with great velocity, encounters the stream of glowing liquid, and carries it along with it in a rush. The steam-jet and the flow of the rock are adjusted with such nicety by the attendant that none of the liquid drops to the ground, but all is caught up by the steam and whirled into the blowing chamber, where it falls by its own gravity. The blowing chambers are oblong rooms 20 ft. to 30 ft. wide, twice as long and about 20 ft. high, and such is the force of the jet of steam that the finer wool is blown to the extreme end of the room, the heavier and coarser settling down nearer the entrance. Having thus been automatically graded, it is packed in bags for domestic use or pressed into bales for export. The bags weigh from 35 lb. to 55 lb., according to quality, and the bales weigh from 150 lb. to 180 lb. When running with a double shift working from 18 to 20 hours the capacity of the works is about 10 tons per day.

The uses of mineral wool are so many that the supply is hardly ever equal to the demand. It is used for packing around boilers, furnaces and pipes to retain heat, and in other places to keep the frost out. It is used in buildings between the walls and in the ceilings to deaden the sound and also to retain heat. During the recent coal scarcity in America it was put to a new use, a wire cage being packed with the mineral wool, which was then impregnated with kerosene and used as fuel in heaters or stoves, and as it is incombustible it would last indefinitely. ('American Machinist.')

(*c*) As carried out by Wood at the Tees Iron Works the process is exceedingly simple. A jet of steam is made to strike upon the stream of molten slag as it flows from the usual spout into the slag waggons or bogies. The steam scatters the slag into shot. As each shot leaves the molten stream, it draws out a fine thread, just in the same way as when you touch treacle lightly with the finger—if you lift it up you will see a fine thread attached. The consistency of molten slag is not unlike treacle; each shot makes a fine thread which, losing its heat, becomes set like glass. The shot being heavy, drops to the ground, but the thread is sucked into a large tube by an induced current of air caused by the steam jets, and the wool is discharged into a large chamber. The finer qualities float about and settle near the outside, whilst the heavier or larger fibres lie chiefly in the centre of the chamber. After each blowing the chamber presents a most remarkable and curious as well as a beautiful appearance. The wool is of snow-white colour, and attaches itself to the sides and roof, or to anything which it can touch, in the same manner as a light fall of snow does in calm weather upon every tiny twig of a leafless tree. The wool is taken up daily with forks, and put into bags for sending away. It is principally used for covering boilers or steam-pipes, for which purpose it is peculiarly adapted, as being a splendid non-conductor of heat, and incombustible. About 4 tons of this wool is produced per week, and as only ½ cwt. is made from each ton of molten slag operated upon, the process is not a very rapid one.

Repeated bursting of hot-water pipes encased in slag-wool induced Professor T. Egleston to examine into the cause. The results he obtained are set forth in the following abstract from his paper on the subject before the American Society of Civil Engineers.

Slag transformed into wool does not differ in any respect from slag in a solid condition, except that its fibres become interwoven. It occupies, when not compressed, a maximum volume for a minimum weight, and thus retains a very large quantity of air. This is its only value: it is the air and not the slag which is required. The only value of the slag is its capability of holding this air when it is not compressed; when it is compressed, it has very little more value than slag in its solid form. This compression may be caused by the sagging of the pipes on it, if only the envelope and not the pipe is supported, or by its becoming soaked with water, when it mats together, water takes the place of the air, and it ceases to be a non-conductor of any value. Its great value is in its very fine fibres, but it is precisely this quality of fine division which makes it most dangerous, for in this condition it is most easily attacked by organic acids, alkalies, or moisture, which not only decompose it, but render the pipes liable to attack. Even the commencement of decomposition causes it to sag and settle.

It would seem, therefore, that mineral wool, if made from slags containing sulphur, is, under certain conditions, a dangerous material. In one case of explosion, the moisture undoubtedly came from defective joints, which are likely to belong to any other system. In the other and far more dangerous one, this moisture was that of condensation; and as it was not expected, every precaution having been taken against it, it is by far the more dangerous one, as it would not be looked for, while every joint would from time to time be visited. In any system, moisture is likely to come from rain or snow leaking through the envelope, where the pipes are exposed above ground in the open air, or, when they are below ground, from drainage water, and, in both cases, from condensation, due to sudden cooling or too sudden heating of the pipes. The effects produced are likely to be all the greater in intensity as the pipes are hotter, this facilitating the liberation of the sulphuric acid, which produces a further decomposition of the slag, and keeps setting free new portions of acid to further decompose the slag and attack the iron. The moment the silica commences to assume the gelatinous condition, the other constituents of the slag are set free to attack the pipes, and unless the leakage is found and stopped an accident is sure to happen. It seems, therefore, a wise precaution, when this substance is used, to employ it only where leakage is not likely to occur or moisture to collect, and to carry the whole system above ground, under cover; or, when it is necessary to carry it below the surface, to have all parts easily accessible, so that it may be carefully examined from time to time. Beneath the ground, where it cannot be examined, it becomes a real element of danger. Kept free from moisture, mineral wool is one of the best and cheapest materials that can be used for covering steam pipes. To employ it successfully it must not become packed, for then it loses its non-conductive power. When it becomes moist, it packs; and if this moisture and packing are continuous the slag is attacked, liberating its dangerous elements to act on and weaken the pipes.

* * *

Smithy Tools. and Their Uses.

Smiths' Work.—Though none but a professional smith could hope to undertake elaborate works in wrought iron and steel, yet many simple jobs can be done with a very moderate amount of practice, such as the bending, drawing down, upsetting, shaping, and welding of the plainer kinds of work.

In a small shop an ordinary forge would be rather cumbersome. Hence one of the small portable forges would be preferable to a mass of brickwork and iron, if it were not for the difficulty of carrying off the smoke. If the forge is to be in a closed building, there must be a hood and chimney. If, on the other hand, it could be placed without the building, protected by a lean-to roof, a portable rivet or similar forge would be lighter and less expensive. The circular bellows in Fig. 72 are either of the single or the double blast type, the latter giving a continuous current of air, but being also the more expensive of the two. Forges with 16 in. bellows are the smallest made, and either these or 18 in. would be the handiest for a small shop. A light framework of bar iron supports the circular hearth. The circular bellows are carried beneath, and are worked by the handle, levers, and rocking shaft, the blast being conveyed through the bend pipe into the back of the hearth.

The ordinary fixed forge is built of brick or stone. The hearth bricks simply enclose a hollow space which is filled with cinders, and upon which the fire is laid. The hearth back is of brick or stone, faced at its lower portion with a plate of iron, through which the tuyere passes, and pierced at its upper portion with a square hole leading into the chimney. The chimney need not be long, its function not being the production of blast, but only of a sufficiency of draught to lead away the smoke. The face of the hearth for a few inches inward from the edges is usually covered with a sheet of cast or wrought iron, for the sake of protection to the bricks. Two troughs occupy the front of the forge—a coal bunk, and a slake or water trough, the two often being made in one casting.

About the cheapest forge which can be made is that shown in Fig. 73, and one which any amateur could construct at a low cost, and with very little trouble. It can be employed out of doors, or placed indoors under a hood and against a wall leading into a chimney. Angle irons for the supports, flat bar iron for the horizontal stretchers, and sheets for the hearth and coal bunk are all that are required. The bearing surface of the angle iron will keep the structure from rocking; but if there is any tendency to unsteadiness when working the bellows, a diagonal brace on each framing will prevent it. The blast may be taken from long bellows placed underneath, and worked by means of a lever handle, set conveniently behind the hearth back, but keyed to a rocking shaft which moves in bearings bolted to the under side of the hearth plate. The rocking shaft passing thus underneath to the front of the forge actuates a lever and connecting rod, completing the connection with the bottom board of the bellows. Or the blast can be taken from a blower at the back, either with single or multiplying gear. A small forge of this type may measure out and out 26 in. long, 22 in. wide, and 30 in. high. The angles may measure 1½ in. × 1½ in. × ¼ in,, the bar stretchers 1¼ in. × ¼ in., and the sheets about ⅛ in. thick.

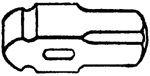
The supplying of the blast is effected either by means of bellows of circular or long pear-shaped form or by fans or by blowers, and in these matters the purse and the convenience of the user would be consulted. Bellows are worked by a handle and rocking staff, and attached to the forge, or distinct therefrom, according to convenience.

A fan is preferable to bellows, and is worked by hand or foot, or power, but should be driven with multiplying gear to get up the speed. In factories a single fan worked by a belt from the engine supplies blast to a range of forges; a throttle valve under the control of the smith regulating the passage of the blast to each forge. Numbers of small forges are now sold very cheaply fitted with fans, or with Root's blowers, so that the old-fashioned leather bellows seem to be doomed to ultimate extinction. A small fan is shown in Fig. 74. The cheeks, A, are of cast iron grooved to a bare $\frac{1}{8}$ in. deep, *a*, to take the strip of sheet iron or brass, B, which is cemented in with white lead and clamped together with bolts *b* passing between the sides. The fan spindle, *c*, is carried in bridge-like bearings, D, bolted to the sides of the cheeks, and the fan itself is composed of dished sides of sheet iron or tin, E, between which the vanes *d* are soldered. The dished sides are soldered to brass rings, *e*, which run against the inner faces of the cheeks. The vanes or blades are also soldered to the curved ribs *f*, on the central boss, made of gun metal. The actual fan requires to be nicely balanced, owing to the high speed at which it rotates. The fan sides are each furnished with a central hole to admit the air. Instead of flat cheeks, two castings can be made with curved outlines, and bolted together with a central outside flange, in the manner so familiarly known in foundry and other fans; but this means the making of two rather troublesome half patterns. The form of blade used in the common old-fashioned fan is shown in Fig. 75, but it is noisy. It is easy to make, the blades revolving within the outer casing, and as close to the sides without actually touching them as possible.

By multiplying gear, we mean some arrangement by which the proper speed of a fan can be imparted without excessive labour at the hand wheel. A hand wheel driving direct to the fan pulley will do, but with multiplying gear smaller wheels and less work will effect the same results. The perspective view (Fig. 76) illustrates this gear, the relative positions of the wheels varying as best adapted to the forge itself, and, of course, a treadle can be substituted for the handle. As drawn, the wheel A would be to one side of the forge clear of the hearth, its bearing being bolted to the hearth back, the bearings of the other wheels being bolted to the stretchers underneath the hearth. 10 in. would be a good size for the wheels A and B. Bands are preferable to ropes running round grooved pulleys, since the latter properly require tightening gear for alterations in length due to temperature.

There is also the tuyere or tue iron to be considered, its function being the conveying of the blast to the fire. The nose of a tuyere would rapidly burn away, and does inevitably burn in time; but its destruction is retarded by the formation of a water chamber behind and around it, a current of cold water being made to circulate by convection within a conical cylinder through which the blast pipe passes, the whole being attached to a cistern or "water bosh." Fig. 77 shows this, the more modern type, in section, and Fig. 78 a section of the older tue iron, made either in cast or in wrought iron. These are illustrative, however, of the tuyeres used for large forges; but the small forges here figured are not provided with a water tuyere, because they are not subject to so fierce a heat as those of larger dimensions, and they are used intermittently. The nozzle which receives the blast pipe is, therefore, simply thickened up in these cases, and the boss piece is cast in one with a back plate, and thus bolted to the hearth back, so as to be readily renewable, as in Figs. 72, 73.

The firing tools are the poker (Fig. 79), the slice (Fig. 80), and the rake (Fig. 81). A ladle is also used for lifting water from the slake trough for the damping down of the fire.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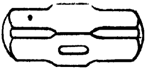
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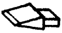
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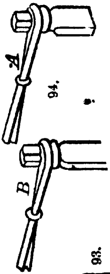

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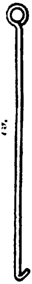
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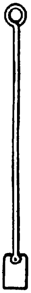
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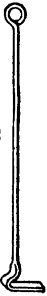
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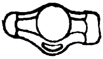
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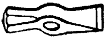
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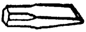
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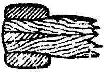
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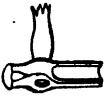
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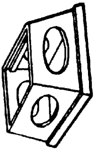
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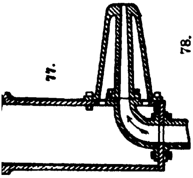
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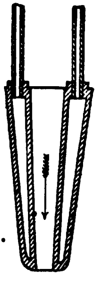
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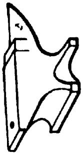
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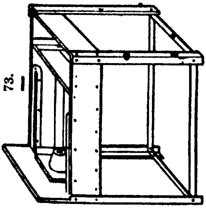
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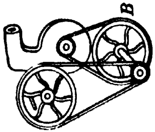

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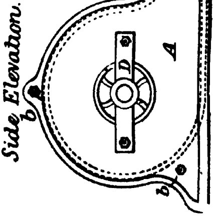
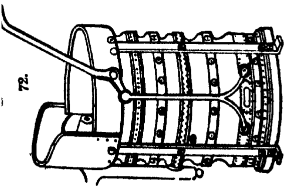


74a.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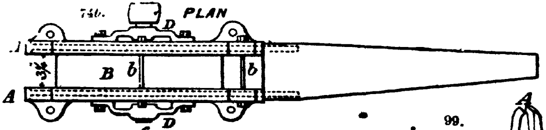
The anvil (Fig. 82), of wrought iron, steel faced, is often supported at its proper height—about 2 ft.—on a block of wood, having spikes driven in at the corners to keep the anvil in place. A much neater and better way is to have a hollow standard of cast iron (Fig. 83) furnished with ledges for the anvil, and with holes at the sides for clearing out the scale and dust. Such a casting is easily made from a pattern by coring out, gives less recoil than wood, and looks neat. Anvils weigh from a few lb. to 4–5 cwt., one of 2 cwt. being of suitable size for light work. The conical end is called the "beak," or "bick," the steel top the "face," the body the "core." There is a square hole, or sometimes two square holes, in the face to receive the anvil cutter and the various bottom tools.

Of the large number of tools of different shapes employed by smiths, those which are in most constant request are the hammers and tongs. After these come the different sets, swages, fullers, and flatters. A smith who works alone is vastly more limited in the number of tools which he can employ than one who has a striker to assist him. When a man is holding his work with the one hand and the hammer with the other, he cannot be holding top swages and flatters and sets as well. But when a two-handed job is required, help can usually be obtained.

Of hammers there are two principal types, each varying in weight and shape, the hand hammer (Fig. 84) and the sledge (Figs. 85, 86). The former weighs 1–4 lb., the latter about 4–14 lb. A hand hammer of 2–3 lb. weight is useful for general work, the lightest hammer, about 1½ lb., being chiefly used by the smith to indicate to his striker at which points to direct his blows, the heavier hammers for drawing down and forging light works. The lighter sledges are used "up-handed," that is, for lifting and striking in a circular arc simply, over the work. The heavier sledges are swung in a complete circle, or "about sledge." The handles of each of these hammers are made of ash, well spokeshaved, and smoothed with glass paper, and are wedged with a single wood wedge, as shown in Fig. 87, wedges of wood being less likely to work loose than those of iron.

Taking the various tongs in order (Fig. 88), we have A and B the flat bit tongs, having flat parallel jaws, the width of opening of the jaws being greater in the "open mouth" A than in the "close mouth" B—the former being used for thick, the latter for thin work, but each being similarly used for the purpose of grasping flat iron bars and sheets. The pincer tongs C are made in two forms, the first being simply concave in the jaws, the second veed as shown, the function of each being the grasping of round, square, or hexagonal bars. The hollow space behind the jaws allows of collars and similar expansions on forged work being enclosed thereby. D are tongs of similar type, but more widely useful, because longer and more enlarged behind the jaws. The "crook bit tongs" E are very common, and are made in various sizes, their peculiar shape permitting of a bar of iron passing down by the handles, while the lip on one jaw serves to retain the bar in place. The "hammer tongs" F grasp punched work, entering into the punched holes. The "hoop tongs" G are for holding rings of thin metal. H are "bolt tongs" for grasping bolts or rings of round bar iron. I J are two forms of "pliers," the latter being in constant use for general light work, picking up light rods, punches, drifts, hardening and tempering tools, etc. K R "hollow bit tongs," made in many sizes for holding rods of circular or other sections, while L and M are "flat tongs," two of the commoner modifications of the last type, and also made in several sizes for grasping flat bars of different widths and thicknesses. These embrace the principal types of tongs, but, like many other tools, they rapidly increase in number, and a single forge will have 20–50 pairs of

74b.



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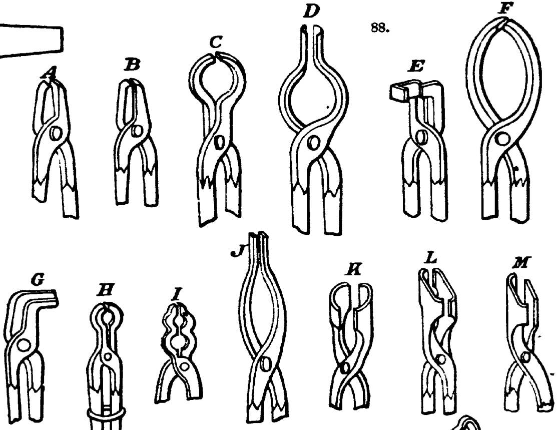

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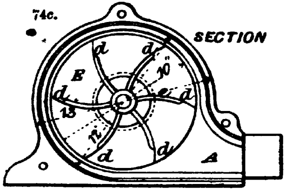

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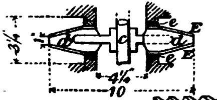
74d.



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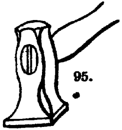

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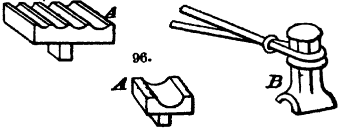

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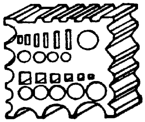

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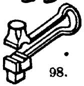

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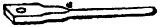


different sizes and in various modifications.

All tongs are made to grasp their work by means of a "coupler" embracing the handles or reins (Fig. 88 H), and just tapped over with a hammer until they tighten themselves, so that the smith has only to turn the tongs and work about, the coupler maintaining a firm hold of the jaws on the work.

For cutting off bars, rounding edges, and rough dressing of forgings to shape, the chisels, or "sets," and the gouges are employed. First there is the anvil cutter (Figs. 89A, 89B), whose shank drops into the square hole in the anvil, before mentioned. The chisel edge being therefore uppermost, when a bar of cold iron is placed across it and struck with the hammer, the bar being rotated the while, the latter is nicked circularly, and may then be easily broken across the edge of the anvil, the fracture appearing of a crystalline character. The "hot" and "cold" sets (Figs. 90, 91) are also chisel-like tools, the difference in these consisting in the angle at which they are ground, the "hot set" being ground thin, the "cold set" relatively thick, and used, as their names imply, for cutting bars hot or cold. These are handled in a similar fashion to hammers, or on withy rods or rods of iron, the sketches indicating both forms and the modes of handling applying indifferently to either. Tools like Figs. 92, 93, differ only in respect to their width and radii, their edges being curved to various sweeps for cutting corresponding outlines on red hot iron. These "gouges" or "hollow sets" are struck by the sledge, the smith holding the tool by the withy handles, while the striker directs his blows on the head. The bevel is either inside or outside; and when cutting through a thick mass of iron it is necessary to withdraw them occasionally, and dip them momentarily in water to prevent softening and loss of temper.

Besides these there are a large number of non-cutting tools of different forms. Chief among these is the "fuller," used, as its name implies, for "fullering" or drawing down iron in a series of grooves, for welding, or for obtaining a flat surface, or for producing a starting point from which to bend a bar. A "top fuller" is shown in Fig. 96, A, a "bottom fuller" or "anvil fuller" at B, the latter resting by its shank over the anvil hole, the former being handled hammerlike, or by withes. The top fuller may be used while the bar rests upon the anvil face, or the bar may rest upon the bottom fuller and be struck by the hammer above, or the bar may be drawn down between the top and bottom fullers, the upper one being struck by the sledge while the bar is moved into successive positions until the iron is thinned or tapered by a series of grooves. The "nicking fullers" (Figs. 94A, 94B) are made in various sweeps, and they fulfil the same purpose for circular shafts and rods that the others do for flat bars.

To finish plane surfaces the "flatter" (Fig. 95) is employed. This is also struck by the sledge, and finishes or flattens the surface, removing the uneven ridges and indentations left by the hammers and fullering tools.

The "swages" form also a very large family in themselves. They are so termed because by their agency work is "swaged" or drawn down and made to assume definite outline corresponding with the shapes of the swages. These are, therefore, dies in principle, because the work can only assume the shapes given to the swages. Being also used in pairs, one top, one bottom, they are commonly called "top and bottom tools." Some shapes are given in Fig. 96. A are bottom swages, that is, they fit by their square shanks into the hole in the anvil face. The shape of the corresponding top swages is seen at B. The ordinary shapes are the half-round, the veed, and the hexagonal, each being required in different sizes. Fig. 97 represents a swage block for a heavier class of work.

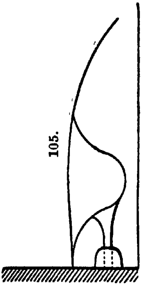
the various sectional forms around its edges answering the purpose of bottom swages. It is conveniently laid upon a cast iron stand, similarly to the anvil, on which stand it can also be laid flat in order that the central holes shall fulfil the functions of "heading tools," that is, of the type of Fig. 103, for finishing the square shoulders of bolt heads and similar flat expansions. The top and bottom swages are frequently united in one with a bent rod of iron, which serves to keep them in line, and becomes a convenient handle. They are then termed "spring swages," or "spring tools" (Fig. 98).

There are three modes of handling tools employed by smiths. The first, just now referred to, of wedging the hammer head fast in the shaft. The second, that made use of with some of the sets, gouges, fullers, and flatters, in which the handle is simply thrust through an eye in the tool without any attempt at wedging, the reason being that their constant and almost close contact with red-hot iron would cause wedges to work slack almost directly. Hence the smith, previous to using either of these tools, usually strikes the butt end of the shaft on the anvil to tighten the head. Lastly there is the method of fixing by hazel rods. These are straight hazel sticks about ½–⅝ in. in diameter, twisted round the necks of the tools (Figs. 94, 96), the elastic wood preventing painful jarring and blistering of the hand of the smith. Before being bent, they are soaked in water and steamed over the fire, the operation being alternately repeated until they are sufficiently pliable to bear bending and twisting, but not taking more than a minute or two. The parallel rods are united permanently by a coupler, and are never taken off the tools except when they need renewal. Very often it is the practice to substitute iron rods for those of wood, as being more durable, the rods being bent in the same manner.

A hook wrench (Fig. 99) is used for giving a slight amount of torsion to flat bars while red hot, which have become twisted or winding in the process of forging. Fig. 101 may be taken as a type of the punches which are employed for piercing holes through red-hot iron, and Fig. 100 of the drifts for enlarging and making them parallel, the work being laid upon a bolster (Fig. 102) the while. Fig. 103 is a heading tool, of which there are several sizes used for shouldering the heads of bolts and rivets, or any work provided with collars, though where a collar is welded or otherwise formed on the centre of a bar collar swages are often used in preference.

As a simple example of the practice of forging, take the connecting rod (Fig. 104), one with a forked end being purposely chosen as being more complete for purposes of illustration. This could obviously be made by building up—that is, the enlargements at the ends could be welded on a bar of the diameter A; or by swaging down, in which the diameter A would be hammered down from a bar of the sizes B or C of the larger ends; or by jumping up, where the ends would be beaten up or "upset" on a bar of diameter A. Or it can be made by a combination of these processes if a bar of medium dimensions only is available.

Say we have a piece of bar of the dimensions A; we can get on very well with that. We build a fire in such a way as to obtain "a solid core of heat"—that is, we have a certain portion in front of, but away at a distance of a few inches from the tuyere, intensely hot, and for the time being open above, but flanked at back and front with two masses of wetted hard-caked small green coal or "slack," which partially confine the heat (Fig. 105), and form a reserve supply for the incandescent mass; and the larger the forging the larger the reserve of "stock." Putting that portion of the bar which requires to be heated—in this case the end—into the centre of the fire, cover it over with a mixture of stock and new coal, so as to enclose it completely, localising the heat where required by keeping wet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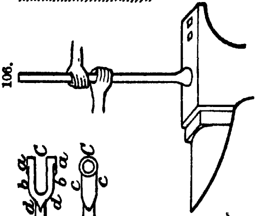
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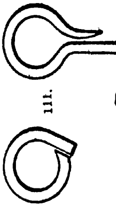
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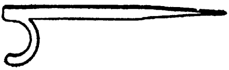
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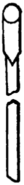
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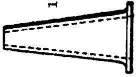
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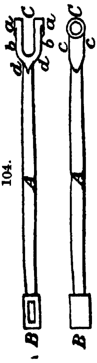
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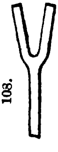
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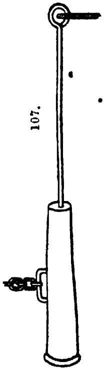
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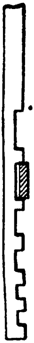
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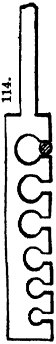
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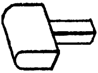
109.

coal over the portion which is not to be heated. Then the blast is put on, and the heat is enclosed and intensified around the bar. The bar, especially if large, is to be turned partly round in the fire now and again to equalise the heat, the blast meanwhile hollowing the fire in the immediate vicinity of the bar; now and then, also, it will be partly withdrawn in order to be sure that it does not get burned. The heat at which it should get taken from the fire varies with circumstances, a full, red heat being suitable for ordinary forging; while for jumping up, and welding, the iron should be white hot, and just beginning to throw off vivid sparks. Beyond this temperature it becomes burned and spoiled. When the bar is at the white heat it is removed from the fire by means of hollow bit tongs and transferred to the anvil, whence we will follow the process through, remembering that in smiths' work the whole manipulation must be foreseen from the beginning, and the tools all be at hand, so that there shall be no hesitation and loss of time and heat. We will first suppose that the hollow of the forked end is to be slotted out of the solid, and then, for further illustration, we will assume that the hollowing out is to be done at the anvil.

While at a white heat we shall "upset" the iron in order to obtain sufficient breadth for the forked end, and to do this a short heat only will have to be taken on the end of the bar. Thus if the length of the forked portion C were 3 in., the end of the bar would be heated only to a length of 7-8 in. If more length is required, two successive heats should be taken. That portion of the bar, then, which lies beyond the part which has to be upset will not become bent or otherwise distorted during the upsetting process, but remain rigid. The upsetting is performed either by jumping the bar heavily end on to the anvil, the hot portion, of course, being downward (Fig. 106), hence also called jumping up, or it is hammered with the sledge, swung in a nearly horizontal arc, the smith holding the bar horizontally on the anvil with the tongs, or a heavy cast-iron monkey (Fig. 107), suspended by a chain, is swung heavily against the end of the bar.

When the amount of jumping up which is required is slight, the first method suffices; for heavy work the latter plans are adopted. Upsetting reduces the length and increases the breadth and thickness, and the enlargement, being very irregular in outline, must needs be made considerably larger than is actually required. At the same time, since the jumped mass will be of a rudely circular shape, being simply an expansion of the shape of the bar, a rough outline of the shape finally required must be imparted to the end by hammering, the hammering and upsetting alternating, so that the iron, still retaining its heat, is hammered approximately level and square on four sides, forming a rectangular block or lump at the end of the round bar, its extreme dimensions being slightly larger than the out and out dimensions of the bosses *a*. By this time it will probably have lost most of its heat, and will go back to the fire to be made nearly as hot as in the first place. By means of the fuller first and the flatter afterward the hollows around the bosses and the flats *b* will be set down, and similarly the flats *c*. The outside rounding of the bosses will be imparted by cutting off a portion of the corners with a hot set, then hammering with an ordinary hammer, and smoothing off with a top swage struck by a sledge. The whole of the black dimensions will remain when finished a trifle over the bright finished sizes, to give sufficient allowance for machining. The rounding off at *d* is first rudely cut with the hot set, or with a gouge tool, the heads of those tools being struck with the sledge. The angularities will be beaten down rapidly with the hammer, and a top and a nicking swage with suitable curves be used to impart a finished outline.

The bar will now go into the fire again, and the heat will be taken over it extending from the fork to about the centre. A nicking fuller may be used to shoulder down the square bar to a circular section just where it departs from the forked end, or if the bar is small it may be simply hammered at the angles with a hand hammer or sledge. When the diameter is roughly reduced down to the required size next the fork, the original size remaining at the centre, it will be readily finished by swaging, the proper allowance being left for turning. This need not occupy more than one heat. The other half of the rod can be swaged down in another heat. Then there remains the stub end B which has to take the strap, and this will be jumped up in a short heat similarly to the forked end, finished with the flatter, and neatly fullered down around the neck.

In this illustration we have supposed the space between the fork ends to be slotted or drilled out of the solid. But if the forked ends were so wide apart that the slotting or drilling out of the interspace would be considered a heavy task, or if the end were that of a rough lever or pump rod which would not pay for machining, the forks would be forged as follows: If the width of the bar were less than twice the thickness of each fork, it would first require to be jumped up until its width were somewhat more than twice the thickness—that is to say, if the forks were ¾ in. thick, the width of the bar should be rather more than 1½ in., say 1¾ in. or 2 in. As before, a short heat is then taken, extending no further than just beyond the shoulder. The flat portion is laid on the anvil, and divided through the centre with a hot set, cutting first from one side, then from the other, and meeting in the centre.

Sometimes a hole is first punched at the bottom of the hollow. Once divided, it is readily opened out first to the V-shape (Fig. 108), then the hollow is formed by jumping and hammering over a bottom fuller of considerable breadth and depth (Fig. 109), sometimes termed a dresser, or joint dresser, until a rough outline of the bifurcation is obtained. Then the more exact outlines and thicknesses are given in a second heat by judicious hammering, and finishing, partly over the dresser, partly on the flat overhang of the anvil, if the space between the forks is sufficient to permit of this. Finally, when the shaping is done, the forks must be tried for parallelism with the axis of the bar, and if out of truth they will be set over with the hammer.

It is easy to see how a difference in relative proportions would modify the method of making which ought to be adopted, and since our connecting rod is selected, not as of any particular size, but illustrative only of different methods of forging, we will now make it the medium of sundry remarks in reference to the practice of welding.

Upsetting is hard work when the quantity of metal to be upset is large, and particularly so when done without the aid of a monkey, or in the absence of a massive plate which is frequently sunk in the floor for the same purpose. Welding is, therefore, much easier in certain instances. But the stub end B (Fig. 104) is not so much larger than the original size of the bar in the centre; therefore we may upset that very well. Also, when the sum of the widths of the two forks is little more than that of the original bar, and the forks are forged as in the last example, we may accept the jumping up method as being practicable. Moreover, in the first instance described, we upset the bar on the supposition that, though the end was solid, it was not of great width, and this would also be applicable to the ends of many light levers. But assuming the end were both solid and wide, measuring, say, over the bosses three or four times the diameter of the bar in the centre, welding then would be preferable because involving less labour.

When making a weld, there are three points to be borne in mind: to have a joint of sufficient area, and in suitable direction for hammering up; to have the necessary temperature; and to be sure of perfectly clean surfaces. For the first condition, a scarf joint, that is, one running diagonally with the common axis of the pieces to be shut (Fig. 110), is to be preferred, and is, therefore, commonly employed when practicable. When a scarf joint cannot be used, a veed or cleft joint is suitable. When that cannot be employed, a spreading joint, made by fullering down a portion of the bar, is resorted to. A plain butt joint, except when the abutting surfaces are of large area, is seldom used; but flat *surface* shuts are common. The temperature for welding iron is that just now referred to, when the iron begins to sparkle, and to drop off in globules. For steel, the temperature is lower, barely approaching to a white heat. Different qualities of iron and steel require different degrees of heat, and the temperature in each case become a matter of experience. When the ends to be welded are taken from the fire, any scale adherent to the surface must be detached by striking the bar smartly on the anvil, joint face downward, or by sweeping away the scale with a muck brush. If any persistently adhering scale remains on the faces, the shut should not be made.

Fractures occur sometimes from this reason, the weld being perfect near the edges, but faulty in the centre. The joint surfaces are usually dusted with sand, but this is not so essential as it is sometimes stated to be, provided the scale is removed in the manner stated, for numbers of ordinary iron shuts are made without it. The weld is made immediately that the faces are brought into contact, by rapid hammering, every second at the welding heat being of vital importance. When closed together with the hammer, the joint of a good weld should not be visible, the presence of a black line indicating that the shut is imperfect. If during hammering the bar becomes reduced or drawn down below its proper size, diameter, width, or thickness, as the case may be, it must be slightly jumped up to thicken it sufficiently, and then swaged circular, or smoothed with the flatter. Iron and iron are easily welded, so are the milder varieties of steel; but some hard and brittle steels require tact and practice to weld properly, and some, if heated over a certain temperature, crumble under the hammer.

In a connecting rod, the cotter way in the stub end is usually drilled and filed out, but in many instances cotter ways and holes of other shapes are punched and drifted, either to save the labour of drilling previous to filing through, or as being suitable enough for the purpose which they have to fulfil. Before punching, the iron is brought to a welding heat, or nearly so, laid upon the anvil, and the punch, struck with the hammer, is made to pass half way through from one face. It is then knocked back, the iron turned over and punched from the opposite face, the holes meeting, therefore, in the middle or thereabout. Then a drift is inserted in the hole, and either driven half way in from each side, or right through, according to circumstances. While the drift is still in place, opportunity is taken of giving a rough kind of finish to the exterior outline. Punches and drifts become red hot, and soften and bend if they remain more than a few minutes in contact with the iron, so that it is necessary to remove them once or twice from a deep hole and quench them in water. Punches and drifts are usually picked up with the pliers, though the former are sometimes finished with withy handles. They are circular, oval, or rectangular in section, the difference being that while a punch is tapered, a drift is parallel for a considerable portion of its length, and tapers only toward the end.

When bending work, various devices are resorted to. A turn-down edge at right angles would be bent over the edge of the anvil, the flat of the bar lying horizontally across the anvil, the smith grasping the tongs, and steadying them against his leg to resist the force of the endlong blows. The bar is frequently nicked across slightly with a fuller previous to bending, and the fuller, having a circular section, does not divide the fibre as a set would do. Eyes or rings are bent around the beak of the anvil, whose tapered outline permits eyes, rings, loops, and curves of many different diameters being bent. Fig. 111 shows the method of welding a ring and an eye. Rings of large diameter are finished on the conical mandrel (Fig. 112). Small rings are finished on a parallel bar or mandrel of suitable diameter, the bar remaining in place while the outside is finished with flatters or swages. When eyes are being bent, or other work being performed on bars of considerable length, the trouble of supporting the opposite end is saved by driving a rest (Fig. 113) into the ground, and placing the bar in the hollow.

When doing forging it is necessary to take measurements rapidly—not an easy task with hot iron. Hence, gauges notched to different sizes are made of sheet iron, say ⅛ in. thick, the size of each notch being stamped above it, Fig. 114 being a gauge for round, and Fig. 115 one for flat bars. ('English Mechanic.')

Orange	2010° F.
Bright orange . .	2190
White heat . . .	2370
Bright white heat .	2550

Welding.—The following abstract of a paper by G. Newcombe, the secretary of the Cleveland Iron Trade Foremen's Association, will be found a valuable addition to the literature of the subject.

Conditions.—Newcombe calls attention to the ambiguity of language in which the conditions for an effective weld are often stated, and introduces extracts from some of the latest writers on the subject. Edward Williams, at the conclusion of a paper "On the Manufacture of Rails," read before the Iron and Steel Institute in September 1869, said welding was the one thing needful; and we should never lose sight of it. The chance of obtaining thorough welding would be much increased by not insisting on more toughness and fibre than is absolutely necessary to guard against so much brittleness as would bring about breakages of the rail in work. In the discussion on that paper, Sir William Armstrong said that in the manufacture of guns on the coil system, a perfect welding is just of as much importance as it is in the manufacture of rails. The conclusion arrived at, both at Elswick and Woolwich, was this, that in proportion as the iron has a steely character, so in proportion is it unfavourable for welding. The indication of its steely character was obtained by taking a specimen of iron heated to a certain point, and then plunging it into water. If its tensile strength was found to be increased beyond a certain limit, it was rejected as unfavourable for welding. The iron welds most perfectly which undergoes no increase of strength in the process of hardening. Williams, in reply to questions, defined good welding to be a combination of effects, an actual amalgamation of the surfaces, and soldering together by means of the cinder. In proportion as there is more of the absolute contact and less of the soldering, so is welding good, and *vice versâ*. Where there is no contact of the actual metallic surfaces, and nothing but the soldering of the layers together by means of the cinder, it is poor welding; and it is the poorer the thicker the cinder. Where you have a large proportion of surface actually brought in contact with the layer next to it, then you have good welding. But perfect welding—that is, complete contact of surfaces, or anything at all approaching it—is impossible.

Mattieu Williams, in treating on lamination and blistering, says that when a blacksmith makes a weld in a common open fire, he throws sand on the surface to be joined, the object being to flux the scale—that is, to convert the oxide into fusible silicate. This being done, he brings the fluxed surfaces together, and by hammering forces out the liquid silicate, and thus brings clean surfaces of pure iron together, which at a proper heat unite perfectly. If he had a film of oxide between the surfaces it would prevent welding. Following up this principle, Mattieu Williams obtained from the potteries some "slip," or finely-ground flint used in glazing earthenware, mixed this with sufficient water to form a sort of paint or whitewash, and with a whitewasher's brush painted it over the surface of the piles on both sides of each layer. He treated several piles of the finest quality of iron in this manner. They were rolled into boiler-plates, none of which showed any signs of lamination. He believes that by this means lamination may be effectually prevented.

At a meeting of the Iron and Steel Institute, Richard Howson, in a paper read before that society, "On Welding Iron," said that in order to obtain complete metallic contact, the skill of the workman had to be exercised—1st, in heating the iron sufficiently; 2nd, in protecting the surface from oxidation by means of a flux; 3rd, in forming the surfaces in such a way that the flux has a means of escape when the ends are closed up under the hammer.

Having thus given a *résumé* of the latest theories on the subject, Newcombe examines them from a practical standpoint, to ascertain how far they are supported or contradicted by the most advanced practice of the day; and as Howson's views are of the most recent date, and may fairly be supposed to include much that had previously been said on the subject, he takes up the consideration of his conditions—first, on the necessity for proper heats to secure good welds.

Heating.—In point of importance, it rightly stands first, for if the primary cause of defective welding could be traced, its origin would in a majority of cases be found in bad heating.

There is no operation connected with smithing which requires more careful handling, or gives more anxiety to the smith, than the process of welding, for on the successful issue of one weld in the manufacture of a single article may depend either the success or loss of much labour and money. It may therefore repay us to examine with care the conditions to be observed in obtaining a good heat. In the first place, the fuel must be as free from metallic impurities as possible, especially sulphur, as it readily combines with iron, and with it forms sulphide of iron, which is naturally detrimental to the formation of a good weld; 2nd, by a proper construction of the hearth, and arrangement of twyer, to obtain the requisite chemical combination necessary for a proper combustion of the fuel for heating purposes. This is effected by placing the twyer about 4 in. below the level of the hearth for lighter kinds of work, and 6 to 8 in. for heavy kinds. But even with good fuel and the arrangement of twyer just spoken of, we may obtain two kinds of heat—viz., a carbonaceous (reducing) heat, or an oxidising (destroying) heat; the carbonaceous is that which is required by the smith to reduce his iron to a welding condition, to obtain which he must maintain a constant supply of heated fuel between his twyer and the iron to be heated, and covering it likewise if the whole mass is to be heated. The chemical action which here takes place may be explained thus: The oxygen of the air, after passing the twyer, comes in contact with the heated carbon in the fuel; chemical union then takes place; 1 part of the carbon combines with 2 of oxygen, forming carbonic acid; this, in passing through the heated fuel above it, takes up another part of carbon and forms carbonic oxide, which is composed of 2 parts carbon and 1 oxygen; and so long as this action can be maintained, we have a reducing heat suitable for bringing iron into the welding state with the formation of the least amount of oxide on the surfaces of the iron; and if we fail to obtain those conditions, and allow the fuel to become deficient in quantity between the twyer and the iron when it is in a semi-welding state, then we have a chemical action of a different kind, for the oxygen then being in excess, through a deficiency of carbon, readily combines with the iron, and forms a cinder or oxide of iron. This combination results in great loss of iron.

If the destructive effect of oxygen is so apparent on a small sample of iron, an approximate opinion may be formed of the great loss resulting from its action on large masses. In proportion as we obtain heats, under either of the two conditions just named, so shall we get good or bad welding. If the oxidising heat has acted on the iron, it leaves a film of cinder which is difficult to remove, and which prevents close metallic contact of the molecules needful to good welding; this is often apparent in examining large forgings, when turned and polished, that have been laid together or built up in slabs or piles. A dark horizontal line may be traced in the forging, which indicates the junctions of the slabs that in heating have been allowed to oxidise, perhaps through the furnace being too slow in heating, or through the admission of too much free oxygen. The oxide not being properly expelled while under the hammer, the result is a defective shaft, the weakness of which is soon made apparent if in performing its work it is subject to much torsion; whereas, if the mass had been heated in a full carbonaceous flame to that fine mellow or spongy condition so essential to a complete incorporation of the molecules, and which renders iron as nearly homogeneous as can be obtained under the piling system, no such thing would happen.

Fluxes. — He next examines the second section of the conditions just quoted as necessary to secure good welding—viz. protecting the surfaces from oxidation by means of a flux. The views advanced in this section of Howson's argument are so utterly at variance with the best practice of modern times that Newcombe joins issue with him on this subject, as he is convinced that it is not necessary to use any flux in order to secure a perfect weld—that is, if the iron is comparatively free from carbon, and the proper conditions of heating have been observed. Large masses of scrap are welded up in forges, and smaller sections of iron in smithies, without any flux. Indeed, the process described by the author, of piling and rolling large armour-plates at Sheffield, and the manner adopted at Low Moor in manufacturing plates and bars, shows that no silica was used as a flux to assist the welding, other than that which the iron contained when it left the puddling furnace; yet the author admits that his samples were as nearly homogeneous as it is possible to get them without absolutely melting the iron. That welding may be effectively accomplished without the use of a flux, there are few workers in iron prepared to dispute; but as fluxes are used in welding, and chiefly by smiths, Newcombe inquires into the cause of their adoption.

The flux chiefly in use is sand; being abundantly found in nature, it is consequently cheap. It is composed of silicon and oxygen, and technically known as silica. It readily melts on being applied to hot iron; and it is this property, combined with its cheapness, that accounts for its general use. Why is it used by the smith? Because in joining two pieces of iron together different kinds of splicing or scarfing are adopted; those, or at least the most common in use, are of a pointed character, and they present an unequal thickness of iron to the action of the heat; and as the point of the scarf is farthest into the fire, and through its unequal thickness conducts the heat much quicker than the heel or thick part of the scarf, it consequently arrives in a welding state first, and, if the action of the heat was not checked, the point would be burnt away before the heel had arrived at a welding state. To prevent this, the smith throws on or dips the back of the point into the sand; the sand, on coming in contact with the heated iron, melts and absorbs so much of the heat of the part to which it is applied, and on melting becomes vitrified. This glassy silicate readily combines with the iron, and forms a covering to the part exposed to the heat, and being of a very refractory nature, it is some time before it is burnt off the iron. It thus protects the iron in its weak or exposed part, while the other or thicker part is absorbing the heat and arriving at the welding condition. It is sometimes used when the iron is on the anvil, but only when such iron is overheated, and will not bear hammering. A little sand thrown on absorbs the heat and restores its cohesive power. The smith, in using sand, is always careful to keep it from the face of the scarf; he knows from experience that the cleaner he keeps the two surfaces to be welded the closer and more perfect will be the weld. This is the legitimate use of sand in welding; it is employed as a chemical agent to prevent waste of iron, and even in this capacity should be used as sparingly as possible, for its baneful effects are left behind on the forged articles, which, if they have to be either planed or turned, present on their surfaces a series of knotty or flinty points, which blunt the tool and are a source of much annoyance to the operator.

The use of sand is injurious to iron, and though it may be used as an agent to prevent waste of iron in some particular kinds of scarfing, it is not essential to sound welding. In support of this assertion, Newcombe refers to the welding of tires for railways and tubes for boilers; both these articles are continually under inspection for the purpose of detecting flaws or unsoundness, and they are subjected to continual tensile strain and shocks, which tend to develop any flaws or unsoundness; yet how few out of the many thousands in use give way at the weld, and they are invariably welded without any flux being used. Numerous other examples might be given of specialities of manufacture where the welding is done without any flux.

Selection of Iron.—Before closing this subject there is one matter nearly connected with welding which has not received that careful attention that it demands, and which future interests will require—the selecting of iron suitable for welding properly together; not that there is any difficulty in welding Cleveland iron, for it is remarkable for the excellence of that quality, yet there are few districts which produce iron that is more laminated. Perhaps this may, in a measure, be the result of the prosperity of the past few years, which has prevailed in the iron trade, when quantity and not quality was the great desideratum. In welding hard and soft irons together, the difficulty is to get a heat suitable to both, as it is difficult to define the exact temperature for iron in the welding state, for it differs materially according to the different degrees of quality of iron. The amount of heat which a hard pure iron would absorb before arriving at a proper viscous or pasty condition would be sufficient to destroy a soft impure iron by burning. Iron may be welded at different degrees of heat, varying in colour from a greasy yellow up to a white heat, and if heated beyond this point it becomes burnt, through not being fusible when in an uncombined state. Heat has great influence on iron in altering its condition. A high heat will change a fibrous to a crystalline iron, whilst a low welding heat will allow it to retain its fibrous character. Irons in a welding state possess great affinity or attraction for each other, and this is manifested in a greater or lesser degree according to uniformity of quality. If two pieces of iron are laid together in a welding condition, they readily stick to each other, and, if the surfaces are of moderate extent, it requires some force to pull them asunder. A striking proof of this attraction may be seen in any forge, in the piling of very large masses of scrap containing thousands of pieces, which are heated to a welding state, and then brought out of the furnace, and held in suspension by the middle, between the points of a pair of tongs, and though it may weigh 2 or 3 cwt. there is no difficulty in transmitting it from the furnace to the anvil, during which time the particles composing the mass are held together by atomic attraction, but some mechanical force is necessary to bring the particles into closer metallic contact. The difficulty is not so great in welding hard and soft irons together as in keeping them together after they are welded. In a sample containing five different kinds of iron, of varying degrees of quality, the welds, so far as can be judged from appearance, seem to be perfect, yet if this sample had much work put on it, if it were upset under the steam-hammer, the harder knots would separate from the softer, their structural forms are so different. The fine crystalline form of the Low Moor iron cannot be thoroughly incorporated with the open molecular structure of the common Cleveland. Much of the defective welding found in Cleveland iron is due to this cause: we find on examination a layer of crystal and another of fibre in regular succession throughout the commoner kinds of iron. A low heat is adopted in its manufacture, purposely to retain its fibrous character; the result is the lamination spoken of. This evil is not confined to the manufacture of bars only; the rail trade has suffered from the same cause. Welding, properly performed, is neither a soldering nor gluing process. Neither of those words is applicable to the process. It is possible to get a near approach to complete metallic contact by welding; but as the conditions are so varied by reason of the different chemical combinations in iron, it is impossible, in the present state of metallurgical science, to lay down any fixed rules; therefore, the skill and observation of the workman must supply this want, and be constantly directed to those affinities and combinations which are constantly taking place in all metallurgical operations, under fixed though perhaps undefined laws, which govern the results, and give good or bad work in proportion to the extent in which they are regarded or neglected. ('Eng. Mech.')

Nature of Welding.—In the address of Jordan, President of the Société des Ingénieurs, delivered at the annual meeting of that society in Paris, a novel explanation of the welding of iron is offered. Jordan says that welding is a phenomenon exactly similar to the regelation of water, the phenomena of regelation being these, that if two or more pieces of ice at a temperature not lower than their melting-point, or preferably at a temperature much higher than their melting-point, be pressed together, the liquid water adhering to their melting surface becomes solid at the places of contact, and the two pieces are refrozen into one. Jordan very aptly illustrates the phenomena of regelation by the making of a snowball, telling us that this may be done when snow is at a temperature not lower than 32° F. (0° C.). *i.e.*, the freezing-point of water. Every man will remember that when the snow is very dry, and the temperature of the air below the freezing-point, the snowflakes will not cohere without the aid of much pressure and warmth from the hand, but that with sloppy snow during a thaw, one can make a hard ice snowball with ease. Jordan compares the making of the snowball with the welding of the iron ball, maintains that the processes are identical, and applies Sir W. Thomson's explanation of regelation to the cases of iron and platinum welding.

It appears to Prof. Mattieu Williams that the conditions of solidification in the two cases are not only by no means alike, but are diametrically opposite, the welding of both iron and platinum being effected at a temperature considerably below their melting-point, while the primary condition for the cohesion of two pieces of ice by regelation is that they shall be exposed to a temperature above, or at least not below, their melting-point. In order that regelation should be analogous to welding, it should take place at a temperature far below the freezing-point. Now, it is well known that under such circumstances regelation does not and cannot occur, and therefore it differs essentially and primarily from welding.

If it had been discovered that two or

more pieces of iron, while in a furnace, raised above their melting-point and steaming into fusion, would cohere when pressed together, and that this cohesion resulted from the solidification of their liquid surfaces, in spite of the melting heat of the furnace, we should have an analogy with the regelation of melting ice, and Jordan's conclusions would be justified. Regelation means the resolidifying of a liquid, or a special cohesion in spite of liquidity; welding means a special cohesion in spite of solidity or apparent solidity. If Jordan had described them as examples of curiously opposite actions, the comparison would have been more nearly correct. We might plausibly assume that, while the pressing together of two pieces of wet ice produces a solidification of the surface liquid, the pressing together of two pieces of heated iron has the opposite effect of momentarily liquefying the surfaces of contact, and thereby soldering them together. The plausibility of this explanation is increased by the fact that pressure develops heat, and thus the welding heat might at the surface of contact be momentarily raised to the fusing-point, and then, on the removal of the pressure, this liquid film might solidify and thus produce the welding cohesion. But even this theory is, in Williams's opinion, too learned. A far simpler explanation may be found, and we must never forget that when two or more explanations equally fit a given set of facts, the simpler is the better, and usually the true one.

In order to find a true analogy to welding, we need go no further than the vulgar "sticking together" of two pieces of cobblers' wax, pitch, putty or clay. These are in a viscous or semifluid condition, and they cohere by an action similar to the transfusion or intermingling and uniting of two liquids. Iron and platinum pass through a viscous or pasty stage on their way from the solid to the liquid states, and the temperature at which this pasty condition occurs is the welding heat. Other metals are not weldable, because they pass too suddenly from the solid to the liquid condition. Ice, although it fuses so slowly, in consequence of the great amount of heat rendered latent in the act of fusion, passes at once from the state of a brittle crystalline solid to that of a perfect liquid. It passes through no intermediate pasty stage, and therefore is not weldable, or does not cohere like iron, etc., at a temperature below its fusing-point.

It is usual to cite only iron and platinum, or iron, platinum, and gold as weldable substances, but this is not correct. Lead should be included as a weldable metal. The two halves of a newly-cut leaden bullet may be made to reunite by pressure, even when quite cold. This is obviously due to the softness or viscosity of this metal. Outside of the metals there is a multitude of weldable substances. Glass is a typical example of these. Its weldability depends upon the viscosity it assumes at a bright-red heat, and the glass-maker largely uses this property. When he attaches the handle to a claret-jug, or joins the stem of a wine-glass to its cup, he performs a true welding process.

The chief practical difficulty in welding iron arises from the fact that at the welding heat it is liable to oxidation, and the oxide of iron is not viscous like the metallic iron. To remedy this oxidation, the workman uses sand, which combines with the oxide and forms a fusible silicate. If he is a good workman, he does not depend upon the solidification of this film of silicate, as the adhesion thus obtained would be really a soldering with brittle glass, and such work would readily separate when subject to vibratory violence. He therefore beats or squeezes the surfaces together with sufficient force to drive out between them all the liquid silicate, and thus he secures a true annealing or actual union of pure metallic surfaces.

Cast iron or steel containing more than 2 per cent. of carbon cannot be welded, because the compound of iron with so much carbon is much more fusible than pure iron, or than steel with less carbon, and it runs more suddenly and directly from the solid state into that of a liquid, and hence presents no workable range of weldable viscosity. (Mattieu Williams, 'Iron.')

Recipes.—Steel.—(1) An excellent composition for welding cast-steel is prepared by boiling together 16 parts borax and 1 of sal-ammoniac over a slow fire for 1 hour. When cold, grind it to powder. The steel must then be made as hot as it will conveniently bear, and the composition used the same as sand.

(2) There is one point in welding steel which cannot be too strongly insisted upon, and that is that the pieces, after having been brought to welding-point, should not be struck heavily with the hammer, but only tapped lightly at first until they have begun to weld; after that, the sledge or steam hammer may be used with perfect freedom. Another important thing in welding steel is the heat. While it is impossible to give any specific rules on this point, the general rule, which will be found to hold good in all cases, is not to heat the steel any higher than is absolutely necessary to effect a weld—the higher the steel is in carbon the lower the heat at which it ought to be worked, hence necessitating heavier hammers—and next, not to finish the operation at too low a temperature. It will be best to work the steel as rapidly as possible, reheat as often as required to prevent working or finishing cold, and anneal immediately after welding the whole piece—not only the immediate vicinity—containing a weld. The annealing heat should always be higher than that at which the piece was finished. Another source of danger to the homogeneity of the finished product is to be found in cold-straightening. The presses in many mills are so constructed as to exert absolute shearing stresses, and are apt to do more harm than any subsequent service can do. Cold-straightening ought to be done at black heat, and the local effects of the press be modified by distribution over a large area. This can be accomplished by the use of broad oak wedges or the insertion of pieces of plank. Generally, plates, angles, beams, etc., have of necessity to undergo more or less hammering in the course of construction, and as this produces effects comparable to punching and shearing, though in a much less degree, it becomes necessary, in steel construction, to modify these effects in the same way by protecting the metal surface with wood, and substituting heavy wooden mallets for sledges. In time, the working of steel in every stage requires care—and, above all, intelligence—and the men engaged in it must be impressed with the necessity for careful manipulation and rational treatment. Undoubtedly the steel must possess the proper qualities for structural purposes in the first place, but then it must also be properly treated subsequently if it is to bring those qualities into the finished structure. (A. Hill).

(3) Shear and double-shear steel are easily welded, and the latter will answer almost all the purposes of cast-steel. Cast steel, however, is more difficult to weld, but it can be done by practice. Care must be taken not to heat too hot, or it will fall to pieces under the hammer. Use powdered borax as a flux.

(4) A mass of ingredients is sold for the purpose of welding cast steel, but the simplest and best method is, according to the "Revue Industrielle," the one employed by Fiala, of Prague, Bohemia. He uses pulverised whit marble for the purpose. The tw pieces to be welded together are heated and, after rolling in marble dust, ar promptly joined together, and sub jected to a good hammering.

(5) Cast-steel can be, and is, successfully welded; but there is greater difficulty in the accomplishment of the process than with other kinds of steel, and it requires a practical hand to make a good job. The precautions

necessary to ensure success are as follows:—Keep it from the air while being heated; heat as quickly as possible; do not make it too hot, or it will burn, and break in pieces when hammered—for cast-steel requires a low welding-heat; strike lightly at first, and increase to heavy blows; do not use coals, for they contain sulphur, and will give the surface of the steel a coating of sulphide of iron; but use coke, or what smiths term "breeze," that is, coal well burnt and the cinders washed. Use the following flux:—Borax ½ lb., washing potash ½ lb., and a small quantity of white glass, powdered; melt together, and when cold, pound it. This flux will dissolve the oxide that forms. Apply some before putting in the fire, to protect surface of work from oxide, and apply more at your own discretion. If wanted to weld cast-steel to iron, the iron will require a greater heat than the steel.

(6) The sand usually employed must be discarded, and borax employed in its stead. Some of the cast-steels require a still more fusible flux than even borax, and sal-ammoniac is mingled with it; 1 of sal-ammoniac to 15 or 20 of borax is sufficient. The best mode of using borax is to put it in an iron kettle or ladle over the fire, and heat it until it discontinues to boil up; when cold, reduce it to a powder. When the steel is somewhat heated, the powdered borax is applied, and when again inserted in the fire, the heat is raised as high as the steel will bear without injury. When at the point of fusion, on to the anvil with it quickly; hit it lightly, very lightly, at first, till it begins to adhere, and increase the force of the blows by degrees. If the joint is not satisfactory, try a second heat with another application of the borax.

(7) It is well known that in order to weld iron in a durable manner its surface must be free from oxide, which formerly could only be effected with a welding heat of 2800° F. Such a high temperature is, however injurious to the quality of the iron, and still more so to that of steel, so that many varieties of the latter could not be welded in this manner.

To overcome this difficulty pulverised borax is used, which, however, cannot be uniformly distributed over the surface of the iron. Lafitte now uses a gauze of very flexible wire, and applies the fluxing agent uniformly to both sides of the gauze, or also to paper. For small surfaces it frequently suffices to form a leaf from the agglomerated fluxing agent and filings. Instead of covering the two surfaces with powder, the wire gauze, which consists of the same material as the substances to be welded, is placed between them and welded in. The welding takes place at a much lower temperature, and the fluxing agent generally volatilizes while the wire gauze melts and unites with the surface.

(8) The cheapest flux is a piece of soft clay. First get your heats to a cherry-red in a clear fire; then just dip in the clay. You will find it form a thin coat on the scarf; then put your heats in the fire, and when you see the clay run off the point of the scarf, it is right to weld; but be careful not to get your heats too hot behind the scarf. In shutting your heats, tap them lightly till you feel them begin to stick, then you can have your hammers down on it.

(9) There are so many grades or tempers of cast-steel now in use (from steel rails to surgical instruments) that there is a great difficulty in understanding what is meant by cast-steel. The old system of steel-making was the converted or cemented process; the converted bars were welded once or twice, then called single or double shear-steel, according to treatment received. In the Huntsman or crucible process, the converted bars were broken up into small pieces and charged into crucibles along with oxide of manganese, etc., and when melted, cast into ingots, hence the term cast, to distinguish from shear-steel. We have three methods by which cast-steel is

produced, i.e., Bessemer, Siemens, and Huntsman (crucible) processes, and the various qualities and tempers manufactured by these are legion. Some of these steels will weld without any difficulty, and some with only the greatest difficulty; some kinds will harden very hard when plunged into water at a red heat, and others, when subject to the same treatment, will bend over and over without showing any signs of a fracture, the sudden cooling having made no perceptible difference; yet both are cast-steel, and probably may have been made from the same process. Cast-steel rails are sold at about 9*l.* per ton, cast-steel for tools at 60*l.* to 140*l.* per ton.

(10) Two points must be taken into consideration chiefly in effecting the welding of steel: it is necessary to render the film of oxidised iron on the surfaces to be united by welding as fluid as possible, and some means must be found to restore to the steel the carbon eliminated during the process of heating to the welding temperature. According to the "Revue Industrielle," Rust considers boric acid the most effectual in performing the former, and ferrocyanide of potassium in doing the latter. Rust considers the functions of the ferrocyanide to be also to restore to the steel nitrogen, upon which he looks as an important constituent of the metal. In 1850 a workman of Mulhouse, Alsace, sold the following recipe for a welding compound: 65 parts borax, 20 of sal-ammoniac, 10 of potassium ferrocyanide, and 5 of colophony. Rust changed it as follows: 61 of borax, 17¼ of sal-ammoniac, 16¾ of ferrocyanide, and 5 of colophony. He states that, with the aid of this compound, welding may be accomplished at a yellow-red, or at a temperature between the yellow-red and white, and that no treatment is necessary after welding. The borax and sal-ammoniac are powdered, mixed, and are slowly heated until they melt. Heating is continued until the strong odour of ammonia ceases almost entirely, a small quantity of water being added to make up for that lost by evaporation. The powdered ferrocyanide is then added, together with the colophony, and the heating is continued until a slight smell of cyanogen is noticed. The mixture is allowed to cool by spreading it out in a thin layer. During the process given, boric acid and chloride of sodium are formed, ammonia being expelled. The same product may therefore be obtained by mixing 41·5 parts boric acid, 35 of dry sodium chloride (salt), 15·5 to 26·7 of potassium ferrocyanide, 7·6 of colophony, and 3 to 5 of dry soda carbonate. The only trouble with this mixture, which gives the same results, is that it decomposes easily, unless it is kept in a dry place.

(11) *Broken Spring Plate.*—Get the length, and then take the part of broken plate which is easiest to handle, and upset it suitable for welding. Make a piece of iron ⅝ in. wide, quite thin at one edge, leaving the other about ⅜ in. thick, something like a razor-blade. Take a welding heat on the part that has been upset, and weld the iron across, having the thick end on the point of the plate. Scarf it for welding, upset the other part of plate, and scarf it so that when welding the piece of iron comes between the two steels. In the first heat—it cannot be done in one—don't strike too hard at first, and thin down any thick edges of the scarfs. Take a second heat, and the result will be, in the hands of an average smith, a good sound weld. If the steel is at all fiery, do not attempt to weld it. Should there be a hole near the broken place, showing, on being heated, any sign of a flaw, make a new plate. The piece of iron welded between facilitates the welding, and also makes up for the length lost in jumping.

(12) *Cast-Iron.*—The Chinese process of welding cracked iron wares by cementing them with molten iron is thus described: In the case, for example, of a cast-iron pan requiring such treatment, the operator commences by breaking the edges of the fracture

slightly with a hammer, so as to enlarge the fissures, after which the fractured parts are placed and held in their natural positions by means of wooden braces; the pan being ready, crucibles made of clay are laid in charcoal and ignited in a small portable sheet-iron furnace, with bellows working horizontally. As soon as the pieces of cast-iron with which the crucibles were charged are fused, the metal is poured on a layer of partly charred husk of rough rice, previously spread on a thickly-doubled cloth, the object of this being to prevent the sudden cooling and hardening of the liquid metal. While in the liquid state it is quickly conveyed to the fractured part under the vessel, and forced with a jerk into the enlarged fissures, while a paper rubber is passed over the obtruding liquid inside of the vessel, making a neat, strong, substantial, and in every respect thorough operation.

SOAP.

(*See also* CLEANSING, *and* OILS AND FATS.)

(*a*) The following survey of the processes of soap manufacture is summarised from a series of Cantor lectures, delivered by Dr. C. R. Alder Wright, F.R.S., before the Royal Society of Arts and reprinted by the Society's permission.

Soaps are substances whose essential composition is that soda, or some body analogous thereto, is combined with an acid derived from an oily or fatty matter as starting point, forming a salt of the nature $\left\{\begin{matrix}\text{fatty acid}\\ \text{alkali}\end{matrix}\right\}$

Natural oils and fats, however, are not identical with the "fatty acids" derivable from them; they are, in truth, a sub-class of salts in which fatty acids are associated not with an alkali or corresponding inorganic body analogous thereto, but with an organic material to some extent analogous to alkalies, but widely different from them in many other respects; this material is *glycerin*, so that the composition of a natural oil or fat may (at any rate in the vast majority of cases) be expressed by the symbol $\left\{\begin{matrix}\text{fatty acid}\\ \text{glycerin}\end{matrix}\right\}$ corresponding with the above written analogous symbol for soap $\left\{\begin{matrix}\text{fatty acid}\\ \text{alkali}\end{matrix}\right\}$

The action of single decomposition taking place when soap is generated by the chemical reaction of a fat or oil (a "glyceride") upon an alkali, may then be expressed in the following form:—

$$\left\{\begin{matrix}\text{Fatty}\\ \text{acid}\\ \text{glycerin}\end{matrix}\right\} + \text{alkali} = \left\{\begin{matrix}\text{fatty}\\ \text{acid}\\ \text{alkali}\end{matrix}\right\} + \text{glycerin.}$$

To this change (as well as to certain other analogous ones) is applied the term *saponification*.

Materials.—Besides the fatty and oily matters a large number of other analogous substances, derived not only from natural sources, but also from various waste products, are employed in the manufacture of soaps of different qualities. As regards vegetable sources seeds and nuts (e.g., wheat and oats, rice and linseed, walnuts, chestnuts, hazel nuts, and cocoanuts), more especially, may be mentioned as more or less markedly oleiferous. Those substances which contain comparatively large amounts of oil usually yield it by simple pressure, or "expression," as, for example, olives, cotton seed, and linseed; others, such as rice, containing too small percentages of oily matters to yield them in quantity by mechanical agencies only, can yet be shown to be capable of yielding them by treatment with appropriate solvents, capable of dissolving out the oily matter and leaving the vegetable tissues, starchy matters, etc., undissolved. This method of treatment is often used in combination with pressure, the majority of the oil being expressed, and the "marc" or residue left being then treated with solvents (such as benzene or bisulphide of carbon) for the purpose of gaining the remainder.

Animal Tissues are more usually "rendered," i.e., heated either alone, or in contact with water, so that the fatty matters may be rendered fluid, and (being lighter than water) may be skimmed off from the top; sometimes chemical agents are also employed for the purpose of decomposing the tissues in which the fat is embodied.

Alkalies.—As regards the sources from which alkalies are derived, *kelp*, the residue left on incineration of seaweed, and *barilla*, the similar ash of "salsoda," and other analogous plants were for a long time the chief sources of soda, thus leading to the use of the term "marine alkali," as applied to this substance; but, during the last century or so, the production of soda from these sources has gradually declined, salt being converted into alkali by means of a series of processes essentially consisting of treatment with sulphuric acid, and heating the resulting "salt-cake" with small coal and chalk or limestone, finally separating the soluble alkali from insoluble calcareous matter, etc., by means of water. Of late years a simpler method (the "ammonia process") has superseded this "Leblanc" or saltcake process to a large extont, the essential feature in the ammonia system being the treatment of salt in watery solution with ammonia and carbonic acid gas under pressure.

Potash.—Somewhat similar remarks apply to potash. For a long period this substance was obtained in a more or less impure form by treating the ashes of burnt wood, etc., with water, and evaporating down the clarified solution obtained, thus obtaining "potashes," which, when refined, gave the purer and whiter material, "pearl-ash"; but latterly large deposits of a mineral analogous to rock salt, but containing the metal potassium instead of sodium, have been largely worked into the alkali potash by a method substantially the same in principle as the "Leblanc" process used in the soda manufacture. Some amount of potash also is now obtained by the calcination of "suint," or the greasy matters washed out of raw wool before spinning and weaving into cloth.

Potash soaps are usually considerably softer in consistency than soda soaps made from the same materials, more especially when certain "fish oils" or "drying oils" are largely used in the manufacture; accordingly, soaps are in practice divided into two classes, viz., soft soaps, which mainly contain potash, and hard soaps, chiefly containing soda as the constituent alkali. The great majority of toilet soaps belong to the latter division; a few toilet creams and shaving soap pastes, etc., however, fall into the former class.

Ammonia is but little employed as a constituent of soap proper as used for toilet purposes, although various processes have been patented involving the intermixture of ammonia with potash or soda soaps, for the purpose of increasing detergence, or of obtaining other real or supposed advantages. The chief sources of ammonia employed industrially are the liquors (mixed with tar) obtained by the action of heat upon coal, shale, bones, and other allied organic matters; and more especially the "gas liquor" resulting from the distillation of coal in ordinary gasmaking. From such liquors pure solution of ammonia, or "spirit of hartshorn," is obtained by the use of appropriate purification methods; when brought into contact with the various fatty acids in a just molten condition, and well incorporated therewith by mechanical agitation, solution of ammonia combines with the acids forming "ammonia soaps" of perfectly definite character, but considerably more prone to decomposition than the soaps of the fixed alkalies, potash and soda. In presence of a slight excess of ammonia, they usually dissolve completely in cold water, forming solutions that froth and lather precisely as ordinary soda soaps; but on boiling the solution ammonia is given off, and a residue of fatty acid combined with little or no ammonia is left. The same result is brought about more slowly at ordinary temperatures. When an ammonia soap is allowed to stand under a bell-jar along with a dish of sulphuric acid (to absorb water and ammonia given off), ammonia is rapidly lost, until the amount left equals one-half that chemically equivalent to the soda present in neutral soda soap from the same fatty acid; the "diacid salt" thus obtained usually loses ammonia on further standing, but far less rapidly than the original neutral salt; the diacid ammonia salts of stearic and lauric acids (the leading constituents of tallow and cocoa-oil respectively) appear to be considerably less unstable under these conditions than those of oleic and ricinoleic acids (from olive and castor oils respectively).

Processes.—The processes in actual use for the manufacture of soap on the large scale are tolerably numerous as regards the number of modifications in general detail rendered necessary or convenient in certain cases; but as regards their general principles they may be conveniently ranked in four leading classes or groups, viz. :—

Group I.—Processes in which fatty acids (or fatty and resinous acids) in the free state are directly neutralised with alkalies (carbonated or caustic) so as to form soaps necessarily devoid of glycerin as a primary constituent.

Group II.—Processes in which the fatty glycerides are treated with alkalies in such a fashion as to saponify them, forming soap and setting free glycerin, the arrangements being such that these two complimentary products are not separated from one another, but remain permanently intermixed.

Group III.—Processes in which fatty glycerides are saponified by alkalies in such a way that the soap and glycerin formed are separated from one another during manufacture so as ultimately to produce soaps devoid of glycerin as an intermixed constituent.

Group IV.—Processes virtually consisting of combinations of methods of some or all of the preceding types.

Besides these leading methods, however, there are numerous subsidiary processes, through which soaps made in accordance with one or more of these methods are subsequently put, either separately or jointly, for the purpose of finally obtaining improved finished products in the form of cakes or tablets for toilet use.

First Group.—As regards the methods of soap manufacture placed in the first group, it may be noticed that whereas formerly carbonated alkalies were mainly used for the purpose of acting upon oleic acid so as to form soap, their use is at present much less frequent, because the saving in cost effected by dispensing with the process of causticising the alkali is now so small (thanks to improvements in alkali manufacture), as not to counterbalance several disadvantages attending their employment, mainly on account of the frothing brought about by the liberation of carbonic acid gas. For preparing hard oleic acid soaps by means of soda, the plant ordinarily employed consists of a steam-jacketted pan, provided with an efficient agitator, such as one consisting of two sets of vertical vanes moving in opposite directions, in such wise that the vanes of the two sets interlace in passing each other. The oleic acid is run into the pan, and heated up by admitting steam into the jacket; the alkaline lye (usually also heated) is then run in gradually with continued agitation, its strength and quantity being so regulated that the mass finally resulting after the operation is completed is not too moist to set into a compact mass on cooling, and so that, whilst the oleic acid is completely converted into oleate of soda, there is not any considerable excess of alkali present; a sensitive tongue being usually the means of judging adopted, and a little more oleic acid or soda lye being added, according as the mass contains too much or too little caustic alkali in excess to produce the desired "bite" or "touch" when the mass is tasted.

When carbonated alkali is used, as in what is known as "Morfit's Process," the pan is usually provided with a "curb," a sort of hoop or funnel affixed temporarily to the top, to avoid overflow during the foaming up caused by the disengagement of carbonic acid, which takes place in accordance with the reaction, precisely similar to that

$$\left.\begin{array}{c}\text{Soda conjoined with}\\ \text{carbonic acid}\end{array}\right\} + \text{oleic acid}$$
$$= \left\{\begin{array}{c}\text{Soda conjoined}\\ \text{with oleic acid}\end{array}\right\} + \text{carbonic acid.}$$

ensuing when vinegar is poured upon natron.

Some manufacturers prefer to boil the oleic acid with weaker lyes, more or less causticised, and generally containing an admixture of salt, such as the liquid obtained by causticising with quicklime commercial "48 per cent. soda ash," a product which contains about 10 per cent. of common salt (and other saline impurities). When the soap is partially formed, it becomes more or less insoluble in the briny aqueous liquor (especially an addition of more salt), so that this latter separates on standing; this "spent lye" being then run off, more soda lye is added, and the boiling continued, and so on in much the same way as that adopted in the saponification of ordinary fats and oils by processes of the third group, which will be referred to by and by. In many cases the oleic acid is not used alone, but admixed with other various fats, etc.; sometimes an oleic resin soap is prepared by treating oleic acid and resin mixed together with caustic alkali, or by separately combining them with the alkali and mixing the products. In this case the compound of resin acids and alkali is prepared by heating together the resin and caustic alkaline lye until complete combination has taken place, the process being effected in much the same way as in the case of oleic acid directly treated with strong lyes, and not salted out in any way. For effecting the intermixture a peculiar kind of agitator is often used, known as "Morfit's steam twirl," consisting of a kind of rotary paddle fixed inside the pan, and made up of a long convoluted tube, with perforations at intervals along its length. This tubular stirrer is connected, by means of a hollow spindle, with the steam boiler, so that, when desired, steam can be admitted inside of it; in this way, not only is the agitator itself always kept hot by the steam, but further continuous jets of steam are made to issue through the perforations, so that rapid heating and most effective intermixture of the contents of the pan are brought about; when resin and soda lyes containing 10 or more parts of anhydrous soda (Na_2O) per 100 of resin are thus intermixed, the product is a more or less alkaline jelly-like material consisting of the soda salts of the resinous acids, and more akin in physical texture to potash soaps than to ordinary hard soaps, but capable of blending with these latter, so as to form the various "yellow soaps" of commerce, of which the "primrose" varieties (made from the palest "window-glass" resin) are the most esteemed.

Another substance analogous to oleic acid is frequently employed in the same way, to form soaps by direct neutralisation with alkali, viz., the "grease" recovered from the waste soapy liquors from dyeworks, calico printing, and the like; this recovered grease is usually obtained in the form of a mixture of free fatty acids with more or less colouring matter and other impurities, being produced either by addition of sulphuric acid to the soapy fluids, whereby the soap is decomposed, and the fatty acids liberated float up to the top, or by forming a lime soap by addition of calcareous compounds, which lime soap is subsequently decomposed by a mineral acid. As a rule, this kind of grease is utterly unsuited from its colour and disagreeable odour for the manufacture of the better class of toilet soaps, even after as complete bleaching and deodorisation as can be effected; but it is often worked up into inferior kinds of "brown Windsor" and similar brown soaps, to which nitrobenzene or other powerful cheap scenting materials are added, for the purpose of overpowering the unpleasant odour due to the fatty matters. Much the same remarks apply to a somewhat lesser extent to oleic acid soaps; unless the acid is purified by redistillation and other modes of treatment, the soap made from it is liable to be too much coloured to be made into any other kind of toilet soap than "brown Windsor" and analogous varieties, whilst a peculiar faint sickly odour is liable to be present, requiring moderately strong scents to be added for the purpose of disguising it.

Second Group.—This group of processes may be conveniently subdivided into three classes, according as the operation is carried out at a comparatively low temperature (so called "cold" processes), at a boiling temperature without extra pressure, or at a still higher temperature under increased pressure.

For the manufacture of soaps by the "cold" process only the simplest appliances are requisite, which is one of the reasons why this process is so largely employed by perfumers and others who prepare their "stock" soaps themselves on a relatively small scale. A pan provided with an agitator is, in point of fact, the only indispensable piece of apparatus; the fatty matter heated to fusion being incorporated with the alkaline lyes in the pan, and the thoroughly mixed pasty mass being then turned out into frames, where the saponification is spontaneously completed. When moderately large quantities of fatty matters (a couple of tons or so at a time) are to be treated, a "Hawes" boiler is conveniently used, consisting of an ordinary horizontal cylindrical boiler, with a shaft running through its axis, and provided with vanes, so that, by turning the shaft, the materials inside the boiler are kept well agitated and intermixed. In order to produce a finished product not containing too large a proportion of water, concentrated lyes must be used; thus, to make a soap containing not more than some 25 per cent. of water, there must be used for 200 parts of fatty matter some 100 parts of soda lye, containing about 23 per cent. of anhydrous soda (Na_2O) and about 75 per cent. of water, including that present combined with the soda as caustic soda or sodium hydroxide ($NaOH$, or otherwise Na_2O, H_2O):[*] such soda lye has a specific gravity of about 1·35 to 1·36 (near 37°–38° Baumé). Soda lye of this strength only saponifies tallow and various other kinds of fatty matter with difficulty, weaker lyes being much more effective in such cases, although lyes of this strength (or something approaching thereto) are most suitable for rapidly acting on other classes of fatty matter, more especially castor oil and cocoanut oil. It hence often results that perfumer's toilet soaps made by the cold process are not thoroughly saponified, fatty matter not acted upon, and the corresponding quantity of uncombined caustic alkali being simultaneously present; this latter constituent, if present in any quantity, renders such soap most objectionable and deleterious to use for persons possessing tender skins, or for infants or others whose skins are apt to excoriate and chafe, or chap readily. Of late years, processes for making soap at home have been advocated on the ground of economy, kitchen fat and waste grease being saved, and when a sufficient quantity has accumulated, this is melted and strained clear, and then well intermixed with a soda lye prepared by dissolving powdered caustic soda in a certain quantity of warm water, the mixture being covered up to keep in the heat, and allowed to stand. The soap thus prepared almost invariably possesses the fault alluded to, i.e., the saponification is incomplete, so that fat unacted upon and uncombined caustic soda are simultaneously present; in consequence, such soap, although possibly very suitable for scrubbing floors, or even for laundry operations, can by no means be recommended for toilet purposes.

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[*] The remaining 2 per cent, being saline impurities, such as chloride and sulphate of sodium. This represents a fairly pure commercial caustic soda; but articles of still greater purity are in the market.

In the manufacture of soft soaps and marine soaps (soaps chiefly made from cocoanut oil, and possessing the property of lathering with sea water), the appliances used essentially consist of a pan or copper, provided with a steam worm or coil of pipe connected with the boiler in such fashion that steam passed through the worm will heat up the contents of the copper. Frequently two worms are provided, one with perforations, so that jets of steam continually pass up through the mass of soap when the connection with the boiler is open, so as to boil up the contents of the copper with "wet" steam; the other without perforations, but connected with a super-heater, or high-pressure boiler, so as to give the means of attaining a higher temperature than 100° C. without blowing steam directly into or through the mass, and thus of evaporating water by means of "dry" steam. *A curb to prevent frothing over*, and a *"fan" to break bubbles* and froth, are also useful adjuncts. The latter consists of a vane revolving on a vertical axis, and adjustable at different elevations as required on that axis, so that it can be made to revolve at any desired horizontal level inside the copper, or altogether removed therefrom. The method of working varies somewhat in different factories, in some cases the whole of the oil or fatty matter to be saponified being introduced into the copper, and the alkaline lye then run in in portions at a time, and boiled up with wet steam after each addition; in others, the oil and alkali being both introduced in portions at a time. When saponification is complete, the mass is boiled down, so as to evaporate water by means of the dry steam coils. In the case of "marine" soaps, an addition of salt or brine, to give increased hardness, or of silicate of soda, to increase the detergent action, or of both together, is usually made by crutching in the materials to be incorporated before framing or whilst in the frame; soaps thus treated, however, are by no means desirable materials for toilet use, either alone or as constituents in a blended mass, on account of their alkalinity; they are, however, occasionally used.

Soaps made under pressure, when of good quality, are to some extent used as "stock" soaps, i.e., as the basis of toilet soaps prepared therefrom by refining or blending together, or otherwise treating to improve the quality. The plant used in their manufacture essentially consists of a pressure boiler, into which the lyes and fatty matter are introduced, the temperature being then raised until the requisite pressure is attained (which varies with the fatty matters, being the greater the less easily saponified). In Dunn's method of working, comparatively low pressures are employed (20 lb. to 65 lb.), the soda lyes being causticised before use; in Bennett and Gibbs' method, carbonated alkali is used in conjunction with much higher pressures (15 to 20 atmospheres), the materials being continuously pumped in at one end of the boiler, and emerging as finished soap, ready to put in the frames, at the other end, and being continuously agitated whilst passing through.

Third Group.—In order to prepare soap on the large scale adopted by "soap boilers" employing the third class of process, in which glycerin is separated from the soap during manufacture, much the same kinds of pans and steam-pipes are employed as those above described, saving that their dimensions are usually materially greater; thus coppers capable of holding 30 to 40 tons, and even more, of soap at one operation, are not infrequently used. The products thus formed may be classified into three groups, respectively *curd*, *fitted* and *mottled* soaps; up to a certain extent the process of preparing all three kinds is the same, the main differences being in the later stages. The fatty matter to be saponified is heated together with caustic lye of sp. gr. 1·05 to 1·09, in quantity not quite sufficient to produce complete saponification, weaker lye being used at first, and stronger being gradually added as the operation progresses; the effect of this is to "kill" the fatty matters or "goods," i.e., to convert them into a kind of emulsion not containing any visible grease. After this operation has proceeded to the requisite extent, a certain proportion of salt (or brine) is added, which causes a separation to take place between the imperfect soap formed and the brine produced by the solution of the salt, the latter sinking to the bottom and retaining in solution the glycerin formed during the saponification; this brine is then pumped away by means of a pump connected with the base of the pan, and the partially finished soap boiled up again with stronger lye so as to complete the saponification. For curd soaps this operation is continued, using the closed steam coils, until by evaporation the soap acquires a peculiar consistency, the lyes running away from the curd on standing, owing to the insolubility of soap in moderately strong alkaline lyes, just as it is insoluble in brine; the curd is then allowed to stand awhile, and finally ladled or pumped out into the cooling frames (boxes of wood or iron capable of being taken to pieces, and held together with nuts and screws), in which it concretes on cooling and standing, forming solid blocks which are subsequently cut up into slabs some 2½ to 3 inches in thickness, these being again cut into bars weighing some 3 lb. each. According to the length of time during which the boiling has been continued, and according to the amount of evaporation that has taken place, so is the quantity of water associated with the resulting curd soap variable between the limits of 20 and 45 per cent.; when comparatively weak lyes run away from the curd at the close, the soap is more moist than when the final lyes are stronger; in any case a certain amount of alkaline lye is apt to remain disseminated through the mass, although the majority of such entangled fluid separates to the bottom of the cooling frames and runs away through perforations for the purpose; the presence of this lye renders unrefined curd soaps somewhat alkaline, and hence less fitted for toilet use than for laundry operations. In order to avoid this, when requisite, the curd is boiled up more than once with weaker lyes, or with weak brine alone, so as to wash out the entangled caustic solution, the lye that separates after each boil up being run off; notwithstanding, notable amounts of caustic alkali and chloride of sodium are often present in curd soaps, due to incomplete separation of lye. Recently, a patent has been taken out for the more complete removal of lye by means of a centrifugal machine in which the pasty curd is placed, and it is claimed that almost entire removal of lyes can thus be effected with proper care: the same result, however, is more frequently obtained by "liquefying" the soap, or "fitting" it, which operation essentially consists in thinning the soap to a great extent with weak lyes or water (partly derived from the steam condensed in heating up with wet steam after partial cooling down), boiling up, and then allowing to stand for a long time, when the mass separates into three layers, viz., a frothy scum, or "fob," on the top, and at the bottom an aqueous mass containing iron (from the pans) and other impurities, which, being heavier, separate on standing, and being usually very dark coloured (especially when soda lyes are used containing small quantities of sulphide) are known as "negur," or "nigre"; the central portion, or "neat soap" is almost devoid of free alkali from admixed lyes and is usually colourless, or nearly so; after removing the fob, the neat soap is carefully ladled or pumped off into the cooling frames without disturbing the nigre, which is utilised in the production of mottled soap or other more coloured varieties. The fitted soap thus obtained always contains a considerable amount of water (usually not far from 33 per cent.) when undried by storage, whilst curd soap that has been boiled on strong lye contains considerably less (some 20 per cent. or thereabouts); the precise amount of associated water depending on the way in which the final boil is effected, and the amount of evaporation taking place therein when dry steam is used. The term "fitting," strictly speaking, relates rather to the production of a mass of a certain appearance or consistency than to the actual degree of purification effected, although the two are intimately associated; thus the soap is said to be of a "fine" or "coarse" fit, acording to the amount of dilution, and consequent separation of impurities, which accompanies the development of peculiar degrees of consistency, judged of in practice by taking up of a portion of the mass on a trowel and noticing how it slides off therefrom, its appearance as it cools, and so on.

When a curd soap is made from materials that yield, beside soda soap, an admixture of coloured matters derived from impurities (iron soap, alumina soap, ferruginous matters from the pan, sulphide of iron, etc.), the character of the cooled mass varies notably with the amount of water present; if much water be present, an action goes on in the cooling frames analogous to that taking place in the fitting operation during the subsequent standing, i.e., the coloured heavier impurities more or less completely sink to the bottom as a dark coloured layer; but if the quantity of water be not in excess of a certain amount, and the rate of cooling be properly adjusted, the matters do not subside, but simply segregate themselves into veins irregularly distributed throughout the mass, leaving comparatively uncoloured soap as the matrix in which the veins run. When cut across, such a soap accordingly shows a marbled or *mottled* appearance. Formerly this appearance was considered a guarantee of quality, i.e., it intimated that the amount of water present did not exceed a certain amount (some 20-25 per cent.); and inasmuch as "mottled soaps" for this reason acquired a reputation, it became customary to enhance the mottle by purposely adding colouring matter, and more especially either iron oxide or solution of sulphate of iron, which, becoming decomposed by the soap, ultimately formed ferruginous insoluble matters in the mass. "Castile" soap, thus prepared from olive oil, accordingly long enjoyed a high reputation, partly on account of the nature of the oil used in its production, partly from the existence of the mottle in it. Nowadays, however, such "appearances are deceptive" to a high degree; a large amount of misdirected ingenuity has been brought to bear, not only on the substitution of cheaper oils for olive oil (a substitution not necessarily involving a depreciation in the useful qualities of the soap), but also in inventing methods of manipulation, by means of which a mottled appearance can be communicated, notwithstanding that the amount of water present very largely exceeds that compatible with the old-fashioned natural mottle. These methods essentially consist in partially cooling down the watered soap, and when it has gained a particular consistency owing to thickening whilst cooling, stirring in the pigment intended to produce the mottle, the segregation into veins then going on during the further cooling and solidifying, just as in the true mottled soaps, which were equally thickened at much higher temperatures owing to the smaller amount of water present.

Fourth Group.—The principal class of manufacturers' soaps coming under this head consist of resin soaps, prepared by intermixing with a boiled tallow or other soap of the curd variety the resin soap obtained by boiling together soda lyes and resin; the crude product thus obtained is almost invariably "fitted" as above described before framing. Many of the resin soaps in use, however, are prepared by acting with alkaline lyes *simultaneously* on fatty matters and resin, so that the saponification of the glycerides and the direct saturation of the resin acids go on side by side.

Resin soaps prepared in one or other of these ways are largely used as ingredients in blended toilet soaps, a more ready degree of lathering, greater toughness and less liability to crack in stamping being thus gained. Some of the best of the cheaper class of so-called toilet soaps are simply fitted resin soaps of a good grade (preferably "primrose"* made with the lightest coloured resin) cut to shape, partially dried, and stamped either with or without the previous addition of essential oils, etc., to scent the mass.† The coarser and darker resin soaps, however, being usually made from much lower qualities of fatty materials (horse grease, kitchen fat, and similar low-class greases), are not to be recommended for application to the skin, although they are actually used to a large extent in the production of soaps which, being tinted brown, do not require the finer kinds of fats and oils in their preparation, so far as colour is concerned; whilst being strongly scented (usually with cheap essential oils or "mirbane") the more or less pronounced disagreeable odour due to the coarse fats is practically disguised, at any rate for a time.

Toilet Soaps.—As regards the manufacture of toilet soaps in general, the subject may be conveniently treated under the following heads:—

I. *Preparation of Soaps by Cold Processes.*—(*a*) Opaque soaps. (*b*) Transparent soaps not prepared by dissolving stock soaps in spirit.

II. *Manufacture of Transparent Soaps from Stock Soaps by Treatment with Spirit.*

III. *Preparation of Soaps by Re-melting.*—(*a*) Processes of re-melting single kinds or blends. (*b*) Incorporation of ingredients for improving quality or giving special properties.

IV. *Machinery and Appliances employed in the Preparation of Bars and Tablets.*—(*a*) Manufacture of "milled" soap. (*b*) Appliances used in the formation of tablets from blocks of molten soap.

Cold Processes.—(*a*) *Opaque Soaps.* On account of the simplicity of the plant required for the manufacture of toilet soaps by processes of this class, these methods have long been employed by perfumers and others, making comparatively high priced soaps on a scale small as compared with that adopted in large soap-boiling establishments.

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* In some districts the term "primrose" is applied, not as in the south of England to a light-coloured tallow-resin fitted soap containing some 33 per cent. of water, but to a distinctly inferior heavily-watered article.

† Resin, either alone, or previously dissolved in glycerin, is sometimes added to soap-masses for the preparation of particular varieties of toilet soaps.

In the preparation of perfumes by the process known as *enfleurage*, cakes of prepared fatty matters, and in some cases oils, are made to absorb the volatile odorous matters given off from delicately scented flowers, by exposing the cakes or oils to a gentle current of air passing through or over a mass of the flowers to be treated; or, in the older way of working, by making a pile of alternate layers of flower petals and cakes and allowing to stand for a day or two, during which time the volatile essential oils of the flowers are to a large extent absorbed by the cakes, when the pile is taken asunder and the exhausted flowers replaced by a fresh batch, and so on until the cakes are impregnated with flower scents to the required extent. By macerating in alcohol the cakes thus scented, or by agitating them therewith, the essential oils are again largely dissolved out from the cakes of fatty matter or the liquid oils thus treated, producing flower essences used by the perfumer in compounding his various scents and perfumes, and leaving behind the fatty or oily matter insoluble in spirit. This undissolved substance, being necessarily composed of fats and oils exhibiting the least possible tendency to become rancid (which, should it occur, would more or less deteriorate the essence ultimately prepared), is a most eligible material for the preparation of a high-class soap, the more so as a certain amount of delicate perfume is always retained; and accordingly the manufacture of soap therefrom by a cold process (so as to avoid dissipating and deteriorating perfume as far as possible) is a branch of business often cultivated by the perfumer. Unfortunately, the necessity of the case prohibiting the application of a high temperature, incomplete saponification (causing simultaneous presence of free alkali and fatty matters not acted upon) is often exhibited by such soaps; and when the greasiness thus produced is avoided, it is usually only effected by the employment of a considerably larger proportion of alkali than that chemically equivalent to the fatty glycerides used; so that, in any case, a notable amount of free alkali is more often present than not.

The amount of high-class fatty and oily matter obtained as residues from flower essence preparations being absolutely only small in amount, these materials are usually supplemented with analogous substances of the ordinary type, such as sweet almond oil, clarified beef marrow, refined lard and the like; often these materials alone are employed. The fatty matters of selected qualities are first melted together and strained clear if necessary; then about half the alkaline lye (sometimes caustic soda only, but often a mixture of caustic soda with a smaller quantity of caustic potash) is gradually added with continual stirring, and the whole thoroughly well intermixed; the remainder of the lye is then gradually added with continual agitation, the temperature not being allowed to rise too high (usually not beyond about 65° C.); after which the soap is run into cooling frames much smaller in dimensions than those ordinarily employed by the boiler of household soaps, covered up, and allowed to stand: usually, the temperature rises somewhat spontaneously, owing to the development of heat as the saponification progresses. Various tinting materials and perfumes are usually added, preferably at as late a period as possible consistent with the possibility of complete intermixture with the mass. Some makers reverse this mode of procedure, the whole of the lye being placed in a suitable vessel provided with an agitator, and warmed, after which the melted fatty matters are gradually added and thoroughly incorporated. In order to obtain a resulting product of proper consistency, lyes must be used of such strength that the total mass does not contain more than about 25 per cent. of water; this is effected by using for 100 parts of fatty matter about 50 parts of lye sp. gr. 1·35 (near to 37° Baumé); such lye, if made from tolerably pure caustic soda, free from any considerable amounts of chloride and sulphate, contains about 23 to 24 per cent, of actual anhydrous soda (Na_2O), and about 75 per cent. of water (including that combined with the soda as hydroxide of sodium); so that about 11·5 parts of anhydrous soda are employed per 100 of original fatty matters. If cocoanut oil (finest quality) be used as a portion of the fatty acid mixture, as is often the case with French toilet soaps, a larger proportion of soda is requisite to bring about complete saponification without introducing too large an excess of alkali than is permissible with fatty matters mainly consisting of stearine and oleine, on account of the much lower mean equivalent of the fatty acids contained therein; pure stearine theoretically requires 10·45 parts of anhydrous soda for perfect saponification, and pure oleine 10·52 parts, whilst palmitine requires 11·54, and cocoanut oil from 14·5 to 15 parts.

The great fault of all processes of this class is that on account of the varying amounts of impurity apt to be present in the alkali used, and of the different equivalents of the various fatty acids contained in the material, *it is almost impossible to rely upon obtaining products of exactly the same character by adhering to any routine method of procedure;* if certain proportions are fixed upon as giving a good yield on the average, some batches are liable to contain an excess of alkali to an objectionable extent, and others to contain unsaponified fat on account of the presence of too little actual caustic soda in the lyes used to effect saponification; these defects being quite apart from the circumstance that it is by no means uncommon to find that unsaponified fat and free alkali are simultaneously present, owing to incomplete reaction between the materials employed; for which reasons soaps prepared by boiling and subsequent purification by fitting, or other equivalent processes, are greatly to be preferred to soaps made by the cold process.

(*b*) *Transparent Soaps made by Cold Processes.*—It has long been known that when tallow or other analogous soaps are dried and dissolved in alcohol, the solution obtained when evaporated leaves the soap behind as a translucent mass; the peculiar molecular constitution of soap, as thus obtained, is spontaneously assumed to a greater or lesser extent by certain kinds of soap when prepared by the cold process, notably in the case of castor-oil soda soap. Addition of a little spirit of wine, or of more glycerin than is formed during the saponification, greatly facilitates the production of this "colloid" form of soap, whilst the same result is also brought about by the incorporation with the mass of sugar, and to some extent of other substances, notably petroleum. To so great an extent is this result effected when a considerable amount of sugar is added (15 to 30 per cent.) that under suitable conditions tallow may be largely incorporated with the mass of fatty matter used, without interfering with the transparency, provided that the saponification is carried out in such a manner as to be complete, i.e., that no unsaponified stearic glyceride remains in the product, otherwise muddiness or spottiness is apt to result. In order to make sure that all the fatty matters employed are actually saponified, it is usual in this country to add a quantity of caustic soda solution, notably in excess of that chemically equivalent to the fatty acids, the excess as found by analysis of many kinds of commercial products of British origin usually varying from about ⅐ to ¼ (15 to 25 per cent.) of the soda actually present in the form of soap.

II.—*Transparent Soaps made from Stock Soaps by Solution in Boiling Spirit.*—It has long been known that ordinary household soaps, when more or less deprived of water and dissolved in strong spirit of wine, are thus separated to a great extent from saline matters, such as sulphate and carbonate of soda; so that the solution thus obtained usually contains a less amount of free alkali relatively to the actual soap present than was originally present; and, further, that the alcoholic solution thus obtained furnishes by distilling off the spirit a mass of purified soap which is more or less clear and translucent after standing until the last traces of spirit have almost completely evaporated. Accordingly such purified soaps, made from first-class fatty matters in the first instance, have long enjoyed a deservedly high reputation as toilet soaps, not only on account of their pleasing appearance (especially when judiciously tinted), but also on account of their freedom from irritating action on sensitive skins through the absence of free alkali in any notable quantity. Further, an admixture of purified glycerin with the mass has long been known as improving the soap, not only by aiding the transparency, but also by rendering the mass more bland and emollient in use; whilst certain kinds of resin, or of resin and glycerin jointly, also produce much the same effect.

From the point of view of the method of manufacture, the class of soaps now under consideration is quite distinct from those varieties of "cold process" soaps which are rendered transparent by the intermixture of alcohol with the mass at a certain stage of the operation, although the physical effect upon the resulting soap is much the same in each case, a colloid modification being thereby generated. In particular the cold process transparent soaps are practically (though not necessarily and unavoidably) always intensely alkaline; whilst the true spirit-made transparent soaps now under discussion are (when properly prepared) practically neutral, partly because they are usually made from fitted soaps containing little or no free alkali, and partly because the solution in alcohol eliminates alkaline salts to a very large extent, if not entirely, should they have been present in the original stock.

During the process of solution, which is effected in a covered vessel forming a kind of still, the alcohol vapour given off is condensed by a worm, either running back to the dissolving vessel, or being kept apart. It is stated that crude methylated spirit, when first used for thus dissolving soap, furnishes a much less unpleasantly smelling distillate, and a similar improvement takes place at each subsequent time of using, so that ultimately a spirit is obtained nearly free from the rankness of the original substance, and consequently capable of giving a much better product, especially if employed to dissolve a better class of stock soap. If a transparent soap containing a high percentage of soap is required, it is indispensable that the residue left in the still, after distilling off as much spirit as possible, should be exposed to slightly warm air for a lengthened period, in order to allow of the removal by evaporation of the last portions of alcohol and water (the latter being mainly that originally contained in the stock soap, which, though usually shaved and dried as subsequently described in the case of milled soaps, is rarely rendered actually anhydrous before treatment). Complete transparency, in fact, is not shown by the raw product, which is usually very muddy until clarified by long standing and evaporation of alcohol, etc. The development of perfect clearness is considerably facilitated by the presence of glycerin or cane sugar to the extent of some 10 to 15 per cent.; resin soaps, other things being equal, usually yield clearer products than soaps not containing resin. A good "primrose" soap thus clarified and rendered transparent by solution in alcohol, furnishes a product very little coloured, about the tint of very light golden sherry; most of the transparent soap of this class as sold, however, is much darker, probably from the use of cheaper and darker stock soaps, or from the development of colour either by alteration of certain constituents in impure alcohol, or by the action of air upon the original stock soap, causing browning. In order to obtain a product of uniform appearance, the lighter coloured batches can be deepened in tone by addition of caramel or other convenient soluble colouring matter.

III.—*Remelted Soaps.*—(*a*) A considerable fraction of the various toilet soaps of British make are prepared by blending together different varieties, by the simple process of remelting them together in a pan provided with a steam jacket. Sometimes the bars to be melted are arranged vertically or horizontally around the sides of the pan, in which a little water is first placed to avoid drying, and are left to themselves to soften and run down gradually, more being similarly added from time to time, and the whole mass being finally well intermixed by stirring or "crutching" by hand, and then cast in frames of smaller dimensions than those usually employed by the soap-boiler; in other cases, the pans are provided with mechanical stirring or crutching arrangements, worked either continuously or intermittently; sometimes, to facilitate the fusion, the bars of soap employed are reduced to chips or shavings by means of a kind of plane worked by hand, or by a rotating blade affixed to a disc, and acting on the same principle. Certain practical minutiæ require to be carefully attended to, in order to obtain a good result with certain kinds of soaps, more especially when several varieties are to be blended together; thus, if the heating be carried on too long, in certain cases the mass thickens in consistency, not merely from drying by evaporation, but also in consequence of a physical alteration in texture; if too much agitated, especially with a rotary stirrer, there is a liability to incorporate air bubbles with the mass, rendering it vesicular and spongy, which is apt to deteriorate the finish of the tablets ultimately formed, although it communicates to them the convenient property of not sinking in water, so that when in use, the tablet does not subside to the bottom of the bath or basin, but floats. If incompletely heated or stirred, small masses of unfused soap are disseminated throughout the whole like plums in a pudding, giving a spotted and speckled appearance, especially when colouring matters are added so as to tint the soap. Such colouring matters, when added in the form of pigments, require to be thoroughly ground and levigated, so as to reduce them to impalpable powder, otherwise they are apt to render the soap gritty; when soluble colours are used, they may conveniently be previously dissolved in some appropriate menstruum, such as alcohol or a boiling aqueous solution of soap. Pigments containing poisonous metals, especially mercury, lead, arsenic, and copper, should be carefully avoided; for although the presence of small quantities of insoluble compounds of these metals in the lather produced during use is not likely to affect persons with healthy skins, there is a possibility, in certain cases, of injurious action; and all such contingencies, even though very remote, should be avoided in a high-class article. At the present day, however, vermilion, red lead, and analogous poisonous metallic pigments of this class, are frequently used, principally because soaps thus tinted will bear exposure to light without fading, whilst if organic (natural or artificial) non-poisonous colours be employed, there is frequently a great liability to bleaching of the colour by exposure to light, for example, in a shop window.

(*b*) It is obvious that the process of remelting and blending together various kinds of stock soaps is not capable *per se* of diminishing the average amount of free alkali present in the materials; but by the addition of suitable ingredients to the mass, more or less complete removal of free alkali may be brought about. In certain cases this result is to some extent effected by incorporating with the mass a small percentage either of resin (alone or dissolved in glycerin), or oleic acid, or even palm oil or other easily saponifiable glyceride, a partial saponification then taking place, so that the excess of alkali becomes more or less neutralised by combination with fatty or resinous acids; but these methods are by no means universally applicable with advantage, although in certain cases they are highly convenient, more especially for scouring soaps used in certain industrial processes in connection with textile fabrics. Boric acid has also been employed for the purpose, the product of its combination with the excess of soda (borax) being well known as a useful variety of detergent analogous to silicate and aluminate of soda, more especially in soaps intended for the laundry, borax being reputed to have a whitening action on linen, etc., cleansed therewith; whether it is of equal advantage when applied to the human skin, however, may well be doubted.

Certain metallic salts, notably sulphate of iron, have for many years been used as an admixture in various highly esteemed soaps, their action partly consisting in neutralisation of free alkali by combination therewith of the acid of the metallic salt, whilst the metallic oxide is set free and serves as a colouring matter; thus "Castile" soap of the old fashioned kind (a far superior article to much now sold under that name) is produced by adding sulphate of iron to the curd, so that some of the free alkali becomes converted into sulphate of soda, whilst the oxide of iron formed as complementary product ultimately gives rise to the peculiar mottle characteristic of that kind of soap. Of course the modern mottles formed by incorporating oxide of iron as such, or analogous pigments, are incapable of producing any action of the nature of diminishing the free alkali by neutralisation, there being no constituent capable of so acting in the colouring matters used.

Metallic salts, other than those of iron, have usually the disadvantage, not only of introducing into the composition metallic substances often of an objectionable character, but also (like iron) of developing more or less marked colour in the mass, so as to interfere with the production either of untinted products or of tablets tinted to fancy; it is evident that if instead of a metallic oxide remaining permanently in the mass, there could be developed a volatile substance removable by evaporation, these objections would be obviated, whilst the advantage of neutralisation of excess of alkali would be retained. Such a result I have recently found to be brought about by the employment of a salt of ammonia (such as the chloride or sulphate) which, when incorporated with the soap in quantity chemically equivalent to the amount of free alkali to be eliminated (a proportion readily ascertainable by analysis of the materials), gives rise to the production of a neutral alkaline salt by the reaction of the ammoniacal salt on the free alkali, and of free ammonia mixed with more or less carbonate of ammonia (according as the free alkali was caustic or carbonated), which latter compounds evaporate and are removed, partly at the moment of intermixture, but more especially during the subsequent mechanical processes through which the soap has to be put in order to prepare finished tablets, the slabs, bars, and partly formed tablets, etc., being necessarily exposed to the air for drying and hardening before the finished tablets are fit for boxing and sending into the market, during which period practically all the ammonia and carbonate of ammonia evaporate. Even should traces of ammonia be retained, they are of no practical consequence, inasmuch as this form of alkali, as is well known, is comparatively destitute of the corrosive action on animal tissues exerted by the fixed alkalies—potash, and especially soda—whence the use of ammoniacal fluids in certain stages of the woollen industries where fixed alkalies would seriously injure the fabrics. Accordingly the patented processes founded on these observations afford a simple and convenient method of getting rid of that *bête noire* of the toilet soap refiner, the uncombined alkali naturally present in the stock soaps employed by him as received from the soap boiler and wholesale manufacture. Obviously the de-alkalisation by this process can also be carried out in the preparation of the stock soaps themselves.

Filling.—The various bodies thus added naturally fall into three classes, viz., (1) substances which are added in small quantity, not as "filling," but in order to improve the quality, and which actually do produce that result to a greater or lesser extent, without introducing any serious counterbalancing injury to the product as a whole; (2) substances added in quantity as "filling," but not producing any serious injury by their own nature; and (3) bodies distinctly objectionable in their nature when intermixed with soaps intended for habitual everyday use by the general public, and not under special medical advice.

Amongst bodies of the first class may be mentioned certain finely-powdered roots, etc., (*e.g.*, *orris*), used as perfuming agents, *vaseline*, *spermaceti*, *beeswax*, *ozokerite*, and analogous substances sometimes employed for the purpose of developing a bland emollient kind of feeling in use. *Glycerin*, either in the quantity formed by the natural saponification of glycerides (as in the cold process), or added in addition to a further extent, may also be fairly ranked amongst these substances, i.e., when employed in a sufficiently pure state.

Amongst the substances of the second class which can hardly be regarded as absolutely injurious, although their presence is at least of doubtful benefit, may be noticed the following, when added in such quantities as to act as "filling" or cheapening agents: *Oatmeal*, *flour*, *gluten*, *gelatin*, *dextrin*, *bran*, *starches* of various kinds, powdered *steatite* and *French chalk*,[*] *china clay*, *pipeclay*, and *fuller's earth*; and purified *petroleum* (in transparent soaps).

The following substances may be named as materials belonging to the third class, i.e., substances used for incorporation with so-called "toilet" soaps, the absence of which would be far preferable to their presence, no benefit of any kind, but distinctly the reverse, accruing to a tender skin from their employment: *Sawdust*, and *woody tissues* not in impalpable powder, *sand*, *pumice stone*, and *gritty matters* of all kinds, unrefined *petroleum* and *shale oils*, crude *coal* and *wood tars*, *naphthaline*, *creosote*, and analogous *coal tar oils*,[†] and, *par excellence*, *alkaline salts*[*]

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[*] Sometimes these materials are stirred up with water to a thin paste, which is run into the remelted soap and well incorporated by crutching, the final product being sold to a credulous public as "milk" soap! When dissolved in hot water, and the liquid allowed to stand, the white clayey intermixed matter subsides, and is readily discernible

[†] A large variety of "medicated" soaps, containing more or less considerable quantities of substances referable to the disinfectant class, are in the market. In a large number of cases, the amount of medicating material thus incorporated (thymol, terebene, eucalyptus oil, oxidised turpentine oils, camphor and similar materials) is so small relatively to the mass of soap as to have little more influence on the qualities of the whole than the essential oils, etc., used as perfumes. Such soaps, when otherwise of good quality (by no means invariably the case), may generally be used for toilet purposes with safety, even by persons possessing pretty sensitive skins; but when any considerable quantity of a powerful agent (such as carbolic acid, or coal-tar oils containing it) is present, such soaps *should only be used by tender-skinned individuals under medical advice.* In certain cases, the impregnation of soap with drugs (such as mercurial preparations) forms a most convenient way of exhibiting the latter to patients requiring them; on the other hand, various soaps exist which claim to contain curative agents not really present at all—*e.g.*, *sulphur*. The use of powerful disinfecting soaps in sick chambers and for nurses, for washing linen, furniture, etc., in case of illness, and similar purposes, is, of course, an entirely different thing from the

of all kinds, especially *pearlash*, *soda crystals*, and *silicate of soda*. Any large admixture of neutral salts, such as sulphates and chlorides (several per cents.), added as hardening agents to hide watering, is also to be deprecated, the more so as they usually accompany the use of inferior materials in the first place.

Milled Soaps.—It has long been known to perfumers and others working on a small scale, that by well pounding in a mortar soaps made by the cold process a thorough intermixture is effected, and in some cases a peculiar texture, or pearly scaly appearance, becomes developed. Of late years these operations, formerly carried out laboriously by hand labour, have been effected by machinery; and the result of successive improvements in this direction has been finally to develop a system of manufacture possessing a number of advantages, one of the most salient of which is that being carried out without heating the soap to any marked extent, the most delicate flower essences, made by *enfleurage*, can be incorporated with soap in this way without deterioration of perfume, such as would inevitably result were these scents employed in connection with molten soap. Another advantage is, that the mechanical crushing and intermixing effected by a proper "mill" causes soap that has been artificially dried to some extent since manufacture to acquire a certain degree of plasticity, so as to enable it to be moulded into shape, somewhat as stale hardened glaziers' putty can be made plastic again by "working" it for some time; so that, in the end, the result is the production of tablets containing smaller amounts of moisture than those formed by remelting processes, and consequently not requiring any long exposure to warm air to dry and harden them before boxing for sale.

The manufacture of "milled" soaps is usually carried out by chipping up into shavings the bars of "stock" soaps used as basis, and subjecting the chippings to the drying action of a current of warm air for some hours, a series of latticed trays (or with perforated bottoms) being employed to hold the shavings, arranged vertically one above the other in a drying chamber, and sliding in grooves in the walls, so as to be readily inserted or withdrawn at pleasure. At the base of the chamber hot water or steam pipes run so as to create an upward current of warmed air passing through the masses of shavings piled up on the trays, fresh air being admitted at the bottom. Sometimes the chamber is fitted, not with steam or water pipes, but with a subsidiary heating vessel consisting of a convoluted steam pipe arranged inside a wider tube through which a current of air is made to pass, propelled by a blowing engine, a fan, or falling water, or aspirated through by connecting the upper part of the drying chamber with a chimney or steam draft.

The slicing up of the soap is usually effected by a machine, consisting of one or more blades, set like the cutting iron of a plane radially along a disc (precisely as in certain forms of household vegetable slicers). Sometimes all the soap is dried down to the required point; sometimes part is pretty thoroughly dried, and the rest used undried. The slicers are placed in a hopper, which gradually delivers them between two horizontal rollers nearly in contact (preferably of granite), arranged somewhat after the fashion of a large coffee-mill; the gearing, however, is so arranged that one of these rollers (No. 2) rotates faster than the other (No. 1), so that the soap slices are not merely crushed in passing between the rollers, but are also subjected to a rubbing action. In consequence, the partially crushed material adheres by preference to the roller

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habitual employment under ordinary conditions of such soaps for the usual personal ablutions; but it may well be doubted, even in these cases, whether it would not be preferable to use ordinary soap, and simply dissolve the disinfecting material to the required extent in the water employed.

moving with greater speed (No. 2), and is carried along with that roller for a half revolution or thereabouts, when it finds itself between roller No. 2 and another similar one (No. 3) moving still faster. In consequence, another crushing and rubbing action is set up (the distance between the rollers being suitably adjusted), and the material becomes transferred to No. 3 roller. Sometimes a fourth roller, moving still faster, is employed, and even a fifth on the same principle. Whatever the number of rollers, the film of thick doughy soap paste adhering to the last roller is scraped off by two sets of doctors with alternately placed scrapers, so as to deliver the scrapings into a box in the form of pasty ribbons some half-inch wide. These ribbons are then transferred back to the original hopper, and the intermixture and crushing repeated, colouring matter, scents, and other ingredients being added and intermixed *ad libitum* during the milling. Usually the materials pass three or four times successively, or even more often, through the mill before they are ground to a perfectly uniform paste; a certain amount of warmth is communicated to the mass by the friction and crushing, which heat must not be allowed to rise to too high an extent.

The ribbons finally obtained are next transferred to a machine, by means of which they are compressed and shaped into bars, which operation is known as "plotting" (*pelotage*). Two principal classes of machines are used for this purpose; one essentially consists of an engine cylinder filled with the ribbons, which are compressed by means of a hydraulic ram,* and finally "squirted" out through a nozzle of such dimensions and shape as may be requisite to form a bar of the desired cross-section; much as lead and "compo" tubes for gas and water supply are manufactured, except that no cooling of the emerging mass is required. The other kind of machine is a modification of the well-known "pug-mill" used in the pottery manufacture, consisting of a powerful horizontal conical screw fitting pretty closely into a conical barrel, with a hopper at the top of the wider end. As the screw revolves, the ribbons fall down from the hopper and are caught in the thread of the screw, issuing under greatly increased pressure owing to the conicality. At the narrow end of the conical barrel the mass passes through a plate perforated with a large number of holes, so that it emerges therefrom as a number of parallel rods: the *vis a tergo* causes these to weld thoroughly together, and to pass through a tapering mouthpiece furnished at the exit end with a die, or stout metal plate perforated with an orifice of the dimensions of the cross-section of the bar ultimately required (*i.e.*, round, oval, square, rectangular, or otherwise as desired). Finally, the bars are cut up transversely into blocks, which are stamped into tablets, and boxed for sale after a certain amount of standing, with exposure to air, to harden, and such dressing and polishing, etc., as may be required to give a nice "finish."

When required to produce a soap free from uncombined fixed alkali from stock soaps containing "free alkali," this may be effected in the mill, in accordance with the patented process referred to in a former lecture, by adding to the shavings, before their first passage through, an amount of an ammoniacal salt (such as the chloride or sulphate) equivalent to the average free alkali in the stock, preferably dissolved in as little warm water as possible. During the successive grindings, the ammonia and carbonate of ammonia formed during the neutralisation of the free alkali become practically all removed by evaporation, which readily takes place from the thin ribbons scraped off by the doctors.

Tablets.—The bars produced by the plotting machines above described simply want cutting into suitable lengths, and allowing to stand awhile, to be ready for the stamping operation which converts the pieces into tablets. For this purpose, machines are employed in which the block of soap (previously lubricated slightly with oil, glycerin, odourless petroleum, gum water, such as that made by adding water to "slippery elm," or other analogous substances) is compressed between a pair of dies, fitting within a ring or box, which determines the size of the tablet. A large variety of stamping machines for this purpose exist; in most, the impression is given by impact (as in stamping medals and coins), the dies being actuated by a lever, or combination of levers, a cam, a powerful screw, or other suitable mechanical arrangement, such that a considerable pressure is given for the instant, and intensified by the momentum of heavy moving parts. In some machines, the upper die driven after the fashion of a pile driver; in others, a powerful pressure is developed by hydraulic agency. A succession of blows is sometimes desirable; sometimes the tablets are shaped by means of blank dies, and then dried awhile, and subsequently stamped again with the final dies, cut so as to give the proper impression. For light work, a press worked by the foot or hand suffices; for other kinds, stamps driven by steam power are required.

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* In the older forms of "cannon" machine a powerful screw, worked by steam, is used to actuate the piston which compresses the ribbons into a solid mass, and ejects them as a compact bar.

In the case of remelted soaps, and cold process or other varieties necessarily cast into blocks, the preparation of bars from the cooled blocks requires to be performed previously to cutting and stamping into tablets. The oldest and simplest method of procedure consists in drawing a thin wire, provided with handles at the ends, through the block horizontally, the operation being usually carried out by two men together, the exact line of cutting being previously marked out on the block; the slabs thus prepared are then cut up into bars, either in the same way, or by a hand-machine carrying a wire, which slices off at each stroke a portion of the slab, forming a bar, the width of which is regulated by a gauge. A variety of slabbing and barring machines are in use for carrying out these operations more rapidly and effectively when large quantities have to be dealt with, as in the manufacture of household soaps; for the most part these consist of a travelling platform, on which the mass of soap rests, and by means of which the soap is propelled against one or more strained wires, so that, as the soap travels, the wire cuts it into slabs or slices. In some machines, two sets of wires are used; one a series of parallel vertical wires, the other a similar series arranged horizontally, so that one motion of the travelling platform effects the division of a block into slabs, and also of each of these slabs into bars. These methods of cutting up ultimately result in the production of rectangular parallelopipeds of soap. To convert these into tablets, they are exposed to slightly warmed air for a short time, so as to produce a surface-film of slightly dried soap, and thus avoid sticking to the dies when they are stamped. Tablets thus prepared are usually made from parallelopipeds smaller than the dies, so that the plastic mass is squeezed out and enlarged superficially (and correspondingly diminished in thickness) during stamping. A more or less strongly defined nearly square or oblong mark is apt to be thus produced, indicating the hardened edges of the small block, and to some extent disfiguring the tablet. To diminish and avoid this tendency, the parallelopipeds are often "dressed," or "shaped," by hand or otherwise, before stamping, so as to attain approximately the shape of the finished tablet, a kind of knife, or a "soap-plane," or a mechanical cutter, being employed for the purpose. The scraps thus produced, together with the ends of the bars and the outsides of the blocks cut off to trim them before slabbing, etc., often amount to a very considerable fraction of the block, especially when of comparatively small dimensions; thus, from 25 to 33 per cent. of the block, and sometimes more (if the block has shrunk irregularly in cooling, requiring a thicker outside slice to be removed in dressing), is usually reduced to scrap, which has to be utilised by remelting, either by itself or along with the next batch of the same kind. This, of course, entails loss of labour and time, whilst perfume is lost by volatilisation, and frequently the soap is somewhat deteriorated, especially if the scrap has to lie by and harden for some time before being used up for another batch of the same colour and kind.

In order to avoid or diminish this waste, it has been frequently attempted to form the cast blocks into bars by compression, without cutting; but hitherto the processes suggested for this purpose do not seem to have come largely into use. One of the earliest methods proposed consisted in placing the block in the barrel of a kind of gigantic syringe, furnished with a piston, by means of which the mass of scrap is gradually forced out through a plate perforated with holes, each of which acts like the die-plate of the barring machines already described in connection with milled soaps, so that the soap emerges as a series of bars. Recently, further developments of this idea have been patented, a hydraulic ram being used to give the requisite pressure, with a special arrangement for the introduction of fresh soap after completion of the first stroke. With soaps sufficiently moist and plastic to "give" under pressure and weld together completely, machines of this sort can be employed to produce fairly compact bars; but many compositions used for toilet soaps crack and flake, when thus treated, to such an extent that the bars ultimately formed cannot be worked up satisfactorily into tablets, inasmuch as, although the tablets formed look all right when finished, yet they are liable to break into pieces when used for washing hands, etc.

A recent patent of Dr. C. R. Alder Wright's avoids this inconvenience, and also does away with the necessity of using moulds or frames for casting the soap into blocks, the molten soap being "squirted" directly into bars by means of a syringe-like arrangement propelling the soap through cooling tubes surrounded by water at a proper temperature, and finally through one or more moderately long final cooling and shaping tubes, furnished with nozzles at the far ends determining the dimensions of the cross-sections of the bars that emerge. When the temperatures of the cooling tubes, etc., are properly adjusted relatively to the nature of the soap operated upon and its speed of passage, perfectly formed sound bars are obtained of any required shape as regards cross-section (just as with the barring machines used for milled soaps). Practically, no loss by formation of cuttings and scrap is occasioned, whilst a considerable saving in time, labour, working space, and plant, is effected.

Instead of tablets, many persons prefer to use globular masses of soap, or "wash-balls." These are sometimes moulded by compressing a mass of plastic soap (previously roughly shaped by rolling between the hands, on a table, or between dished plates provided with handles) between hemispherical dies; but the better kinds are cut from a solid block and turned in a little machine (something like an apple-parer), provided with a curved planing iron which gradually cuts the mass to shape. Sometimes several successive parings, with alternate rests for drying, are requisite.

No matter what the shape of the stamped tablet may be, in many cases it is desirable to give an extra "finish" and polish to the surface by hand treatment, such as rubbing with a cloth or piece of felt moistened with spirit. In many cases exposure to wet steam for a few seconds develops on the surface a film or glaze of remelted soap, possessing an admirable gloss without any further manipulation being requisite.

Substances found in Toilet Soaps as Sold.—A certain portion of the cost of manufacture of a first-class toilet soap depends necessarily upon conditions as to which chemical analysis leads to but little distinct information, these circumstances more especially relating to the costliness of the perfumes used in scenting it, and the amount of labour bestowed in moulding and finishing it. But these circumstances have no necessary connection with the value of the soap *as such*; as regards the main characteristics of a thoroughly good soap, not only can these be satisfactorily ascertained during the course of analysis, but further, in no other way can the absence of objectionable constituents be completely proved.

The list of substances incorporated with various kinds of toilet soaps (partly as adulterants or "filling" intentionally added, partly as constituents intended to improve the article or to give it special qualities), together with the normal materials contained in such products, is a lengthy one, comprising amongst other things, the following:—

Alkalies. Potash, soda, and sometimes, but only rarely, ammonia, present in the form of actual soap, i.e., alkalies combined with fatty or resinous acids.

"Free" alkalies: consisting of these substances present in a form capable of neutralising acids other than that of genuine soap, i.e., alkaline matter not combined with fatty or resinous acids.

Neutral alkaline salts, more especially sulphates and chlorides (also including such semi-neutral salts as borax).

Fatty and resinous acids combined with alkalies forming actual soap.

Ditto present in the free state or as more or less imperfectly saponified glycerides.

Glycerin.

Glycerin "substitutes," i.e., adulterants, more especially sugar.

Pigments and colouring matters.

Water.

Alcohol, volatile scents, essential oils, etc.

Organic materials added either to increase the bulk, or to communicate special qualities, such as powdered odorous roots and woods, farina, gelatin, dextrin, and gums of various kinds; oatmeal, bran, sawdust, and other vegetable matters; also beeswax, spermaceti, vaseline, ozokerite, petroleum, crude coal tar, and more or less purified coal tar distillates, including carbolic acid and creosote oils, and Stockholm and other vegetable tars.

Inorganic materials added for similar reasons, such as fine sand, infusorial earth, varieties of china clay and pipeclay, French chalk and fuller's earth, precipitated chalk, sulphur, and such like bodies.

For the complete analysis of soaps, including the quantitative determination of these and other constituents when present, various more or less successful methods have been propounded by different analysts which are fully described in the works of Carpenter, Lamborne, and others, but it may be pointed out that a considerable experience has led to the conclusion that a very fair estimate of the general character and value of a toilet soap may be formed without quantitatively determining every possible constituent present, the data more especially requisite for deducing such conclusions being the following:—

Total alkali present, including—

Alkali combined as actual soap.

"Free" alkali, i.e., alkali not so combined, but capable of neutralising acid.

Fatty matters present, including—

Fatty (and resinous) acids combined as actual soap.

Ditto, not so combined (free acids and unsaponified fats, etc.).

Glycerin (when present).

Together with qualitative test as to the odour, melting point, and general properties of the fatty acids present; and similar tests (so performed as to give a rough idea of relative quantity) for poisonous metallic pigments (more especially compounds of mercury, as vermilion; copper and arsenic, as Scheele's green, and other analogous pigments; and lead, as red lead and chrome lead), and for other matters insoluble in water (farina, French chalk, etc.), and for soluble matters, such as sugar and sodium chloride, etc.

Testing the Chemicals.—To estimate the commercial value of soda ash or potash, or solid caustic soda, it is necessary to ascertain the amount of water they contain, the amount of caustic and carbonated alkali, the foreign substances in them.

To Estimate the Amount of Water.—One hundred grains of the alkali are heated in an iron capsule over suitable heating apparatus, until all the water is expelled, which may be tested by a plate of cold glass held for a moment over the capsule, when whatever vapour rises from the heated material will be condensed on its surface. After all the water is thus driven off, the loss of weight will indicate the amount of water in every 100 grains of material, and the absolute weight of the dried sample will be the percentage of alkali contained in the crude material; the loss will indicate the percentage of water contained therein.

To Estimate the Amount of Caustic and Carbonated Alkali.—It is very important to ascertain if there is only caustic alkali or only carbonated alkali, as well as the amount of each. For example, if a potash or soda is only one-third caustic, and two-thirds carbonated alkali, the latter must be changed into the caustic state before it can be used in soapmaking. It is best first to determine the amount of caustic alkali. Concentrated alcohol will only dissolve caustic soda, and not in any way affect the other ingredients always found in commercial potash, soda, or caustic soda. Take 100 grains of commercial soda; reduce them to powder in a glass mortar, put half of it in a flask, with the addition of 1 oz. of alcohol of 95 per cent.; shake all well together, and let stand for a few hours, afterwards transfer the liquid floating on the top carefully into an evaporating capsule of porcelain, and let it quickly evaporate over a lamp, gradually increasing the temperature until nothing more evaporates; when cooled, immediately weigh the capsule to ascertain the actual amount of caustic soda which the sample contained. Before the evaporating process is commenced, in order that nothing is lost, a little alcohol should be mixed with the deposit in the flask, and being filtered added to the liquid which had already been transferred. In estimating the amount of carbonated alkali, it is requisite to determine, first, the actual amount of alkali existing in the soda or potash, and this being ascertained, the quantity of carbonated alkali is reduced by calculation. 50 grains of the alkaline sample are to be dissolved in a flask containing 2 oz. of water. Next weigh out, on a watch-glass, 100 grains of well-crystallised oxalic acid, reduced to a fine powder. Small portions of this powder are to be added at a time to the alkaline solution, shaking the liquid between each addition, or stirring it with a glass rod, heating and testing it with litmus paper till the latter becomes slightly reddened, while the liquid is hot. The residue of the oxalic acid is then weighed, and supposing it is 43 grains, it is obvious that to saturate the alkali in the 50 grains of the sample, 57 grains of oxalic acid were consumed; 7·87 grains of oxalic acid are capable of saturating or removing the alkaline reaction of 5 grains of caustic soda, or 7 grains of caustic potassa.

To Determine the Nature of Foreign Ingredients.—These may be soluble or insoluble. As they are not taken up by the lye, the soapmaker need care nothing about the insoluble substances. Generally the soluble ones are found to be chlorides or sulphates. The former are detected by adding a solution of nitrate of silver to a clear solution of the substance to be examined, which has been previously slightly acidulated with chemically pure nitric acid, and if there is chloride of potassium or salt present a white curdy precipitate will be formed, which, by exposure to light, becomes first violet and afterwards black. Sulphates are detected by first neutralising the solution with nitric acid, and then adding a solution of chloride of barium ; a fine heavy white precipitate is formed. To many it is of importance to ascertain if there is any sulphide of sodium, because a potash or soda containing it would be unfit for the manufacture of white soap. It is often detected in the potash and soda, but never in the caustic soda. Its presence will be indicated by the development of hydrosulphuric acid, on adding an acid to a solution of the alkali, a gas very much resembling rotten eggs in its smell. Where the odour of the gas fails to afford sufficient proof of the presence of hydrosulphuric acid, the application of the following reagent will remove all doubt. The air suspected to contain it is tested by placing in it a small slip of paper, moistened with a solution of acetate of lead ; if the gas is present, the slip will be covered with a thin, brownish-black, shining film of sulphide of lead.

Preparation of the Lye.—*Water.*—Only spring or river water should be used in making soap. It must also be perfectly clear, otherwise clear lye cannot be produced. It must be free from organic matters, for these are often dissolved, and, though imperceptible, soon cause the water to become putrid. Nearly all waters contain mineral matters in solution. When such waters are used, though the lyes are equally good, there will be a loss of material in proportion to the quantity of alkali neutralised. A water containing more than twelve grains of such substances in one gallon should be rejected.

Lye.—Lye is an aqueous solution of caustic soda or potassa, by the agency of which the chemical decomposition of the fat and its conversion to soap are effected. Caustic soda is a commercial commodity, but it may happen that the soapmaker will have to prepare his own lyes. (1) Reduce the soda or potassa into small pieces, mix it with slacked lime, let it stand 24 hours, and then leach it out with water. For this purpose large tanks are used, having a perforated floor, placed from two to four inches above the bottom, and covered with a layer of straw, on which is poured the mixture of lime with the alkali. A faucet is inserted between this perforated floor and the bottom, by means of which the liquor can be drawn off. The lyes prepared in this way are never perfectly caustic ; whilst in this process more lime is requisite than when the following method is adopted, which gives a perfectly caustic soda. (2) The potash or soda, not too concentrated a solution, should be thoroughly brought together with lime-milk, this process being assisted by heat. Insoluble carbonate of lime forms, which settles at the bottom. There should not be more than about 15 per cent. of alkali in the solution, otherwise a portion of the carbonated alkali will remain undecomposed. For the thorough decomposition of the carbonates of the alkalies, the process of boiling must be continuous and uninterrupted, and the lime of a milky consistency. To ascertain whether the lye is caustic, take a test-glass full, let it stand till cool, then filter, and drop into the clear liquid some nitric acid ; if it effervesces, the lye is not caustic; the boiling has to be continued till the portion taken from the kettle shows, when filtered, no escape of carbonic acid if nitric acid be added. As soon as no carbonic acid escapes from the lye, the fire should be taken out, the liquor carefully covered, and suffered to remain undisturbed for 12 or 15 hours, so that the lime may settle. After this, the clear liquor should be transferred by a siphon into a wooden vat, lined inside with sheet lead, and having a perforated false bottom, and cock fitted near the bottom so that the clear lye may be drawn off. The lime used must not have been exposed to the atmosphere; only the quantity actually required should be slacked at a time, because the hydrate of lime, as well as the lyes, loses its causticity when exposed to the air. For 100 lb. of crystallised soda, 24 lb. of quicklime are required; for 100 lb. of pearlash, double that quantity; and for 100 lb. of soda ash, 60 lb. will be required. For the transformation of pearlash or soda into caustic lyes, more or less quicklime is necessary, according to the amount of carbonated alkalies they contain, and an excess of lime will do no harm.

Bar Soap.—The ingredients given are for making about 1 cwt. of soap at a time. 15 lb. tallow, 15 lb. sol. soda, 56 lb. resin, 28 lb. stone lime, 10 lb. palm oil, 56 lb. soft water. Make a caustic lye of the soda and lime by boiling them in the water until the compound is homogeneous.

In a second boiler heat the resin, tallow, and palm-oil (the addition of the latter gives an agreeable yellow colour to the soap), and stir well until thoroughly incorporated.

Now gradually mix the lye with the melted tallow, etc. (both compounds being boiling hot), stirring all the time while adding the lye, and for 15 to 20 minutes after (the exact time can only be determined by actual experience), but do not stir too long or the saponaceous mass will separate again. Endeavour to stir the mass so that it does not show any streaks of soap and lye here and there, but presents a uniform appearance.

The apparatus needed is two boilers which can discharge their contents simultaneously into an iron tank about 18 in. in depth, and as the contents of both boiling kettles are run into the tank, an operator at each side with a long paddle or stirrer should well mix the contents. When the mixture has been sufficiently stirred, leave the mass to settle for some hours (12 to 24), then, if a clear separation of the soap from the lye underneath has not taken place, sprinkle some common salt, not too much, over the surface of the soap, and if the latter is fluid enough stir up just sufficiently to allow the salt to mix with it. This will expel all alkaline water from the soap, and permit it to float on the surface of the liquid in a semi-hard mass. After a few hours more rest, draw off the liquid beneath the soap and allow the latter to remain undisturbed until hard enough to cut up.

If preferred, instead of doing this, the semi-fluid mass can be ladled out into wooden moulds or boxes, the insides of which have been moistened with water to prevent the soap adhering, and thus when the soap is sufficiently hard it can be cut up into bars in the usual way.

Carpet Cleansing Soaps.—(1) Mix together ½ lb. fullers' earth, ½ lb. carbonate of magnesia, 2 oz. of pipe clay, in a quart of ox-gall. Apply with a sponge. Or it may have ½ lb. soft soap added and then be used with the water intended to wash the carpet. This mixture revives the colours.

(2) ½ lb. Castile soap, ½ oz. fullers' earth, ¼ lb. carbonate of ammonia and 1 oz. ox-gall. Mix together and then let it dry into a soap. It is used as soap with warm water, brush and flannel.

Cocoanut-oil Soap.—Cocoanut oil acts differently from any other fats, in combination with which weak lyes produce a milky mixture. Such lyes have no effect upon cocoanut oil, for it can be seen floating on the top, while strong lyes of 25° to 30° very soon produce saponification throughout the whole mass. This soap is sometimes called marine soap, as it will lather well with sea water. A lye of 27°, cold weighed, will saponify an equal weight of cocoanut oil—100 lb., for instance, making nearly 200 lb. of soap. The oil is put in the pan together with the lye, and then heat is applied. After continually stirring it for 1 or 2 hours, the paste will gradually thicken, when the temperature of the heat applied should be moderated, but the stirring continued, After a time the paste turns into a *white semi-solid mass, which forms the soap, and this has to be filled immediately into the frames, because solidification takes place very quickly.* A mixture is often used of equal parts of tallow and cocoanut oil, or of bleached palm oil and cocoanut oil, which yields a very fine soap. 90 to 95 per cent. of cocoanut oil, with 5 to 10 per cent. of natural palm oil, yields also a nice soap; and all these fats, when mixed with cocoanut oil in not too large proportions, will be as easily saponified as if the latter alone were used.

Colouring Soaps.—For the colouring of ordinary fancy soaps, mineral colours are employed; for superior toilet and transparent soaps, organic pigments are used. Generally, the red colouring matter is derived from vermilion or chrome red, the violet from fuchsine solved in glycerine, the red-brown and brown from caramel and the various kinds of umber. For green, chrome green is used; a beautiful vegetable green is obtained by stirring in the soap, saponified with 7 to 10 per cent. of palm-oil, some smalts or ultramarine. For blue, smalts or ultramarine. Yellow is obtained by mixing palm butter with the fat to be saponified. For black, common lampblack is used. Fine toilet soaps and transparent soaps may be coloured as follows:—For a red colour, tincture of dragon's-blood or liquid carmine. Rose, tincture of carthamine or of archil. Yellow and orange, tincture of annatto or saffron. Blue and violet, tincture of litmus, or of alkanet-root, or soluble Prussian-blue, basic, or a very little pure indigo in impalpable powder. Green, a mixture of blue and yellow.

Dye Soaps.—The base is any plain white or yellow soap. Prepare a dram of analine dye by dissolving it in 2 oz. of alcohol and 2 oz. of water, and work this quantity into each pound of soap. The resulting coloured paste is then moulded to shape.

Engineer's Soap.—The following recipes produce cheap but effective soaps for the use of engineers, mechanics and others engaged in rough and dirty work:—

Take 5 lb. caustic soda powder (98 per cent.) and place it in a vessel containing 2 gal. of water, stir until dissolved, and let the lye thus produced remain until cold.

In a larger vessel suitable for mixing bulk, melt over a slow fire 35 lb. of tallow.

Mix separately 5 lb. ground silica and 5 lb. china clay with sufficient water to make it of the consistency of thick cream, and when thoroughly soaked strain twice or oftener. The moment the tallow is melted, pour the silica and china clay slip into it, stirring constantly until incorporated, and then pour in gradually the caustic soda lye, and stir until perfect amalgamation is attained. Pour out the liquid soap into a box and keep in a warm place well covered up for 24 hours, when it will have set into a block, which may be cut up and pressed if desired.

The process of melting must be very carefully carried out, only sufficient heat being used to warm the tallow, etc.

Floating Soap.—To 28 lb. of good oil soap add 1 qt. of water and melt in a steam or water bath. The bath or pan should be fitted with an agitator, as it is essential that it be worked well and continuously until the soap has doubled its volume. Pour into the cooling frames and, when cool, cut in the usual way. It is a pleasant soap to use, but not economical if purchased by bulk or piece. It may be perfumed with any required scent.

Hard Soaps.—Hard soaps are always soda soaps. There are grained soaps, those in which a separation of the under-lye has been made as described, and filled soaps, those in which the whole contents of the boiling pan are kept together and sold as soap. The cocoanut oil is especially employed for the manufacture of filled soaps, because it is easily soluble in brine, requiring a very large quantity to separate them, and then they become so hard that they *can scarcely be cut with a knife.* The more solid constituents a fat contains, the harder the soap produced; *the more oleine, the softer the soap.* By mixing the fats in different proportions, soaps of any consistency can be obtained; this also depends upon the strength of the lye used in the process. Weak and middling strong lyes will produce a light soap, while lyes of 25° to 35° B. will produce a soap heavier than water. Sometimes a small admixture of sulphate of soda is employed in making soap, for the purpose of preventing its too great solubility when used in washing. In the manufacture of soaps, ⅓ or ¼ of fat is frequently substituted by resin. For the transformation of 100 lb. of fat into soap, there are generally necessary 12½ lb. of solid caustic soda; this quantity must be more or less, in proportion to the nature of the fat.

Hard-water Soaps.—In order to reduce the waste of soaps in contact with hard waters, through double decomposition brought about by the lime and magnesia salts, Funk and Eltze, in 1877, patented the use of sodium phosphate; and in 1890 Grimshaw claimed novelty in the addition of "an alkaline phosphate," with the object of forming calcium and magnesium phosphates, instead of lime and magnesia soaps, which are insoluble in water and therefore wasted.

Harness Soap.—Take 10 lb. of resin soap and put it to melt with sufficient boiling water to just thoroughly soften it. Work into it 4 lb. of sperm oil (previously warmed) and add sufficient fine bone-black until a nice paste is obtained.

Marble Soap, for cleansing marble. White soft soap 10 lb., powdered pumice 5 lb., whiting 4 lb., pearl ash 8 lb. Grind all to a stiff mass, adding a little water if required. Press into moulds.

Medicinal or Medicated Soaps.—As soaps of this kind are intended to have curative properties, it follows that the soap base from which they are made should be pure. *It is also necessary that the raw ingredients being of best quality excess of alkali must be carefully avoided as being likely to cause roughness and scale on the skin.* Voiry's method is considered a good one, possibly the best, this requiring a plain cocoanut oil paste soap as the base. This base is prepared as follows: 24 parts by weight of cocoanut oil are boiled in a porcelain vessel with 16 parts soda lye (10° B.). This forms a cream to which is added 10 parts soda lye (20° B.). The boiling is continued until a little of the mixture, dropped on a cold surface, solidifies. A quantity of distilled water is then added, and the boiling continued and 10 parts of common salt added. When the soap is cooled it separates and is then subjected to twice washing in a 20 per cent. solution of ordinary salt and afterwards in distilled water. The whole is then pressed to expel excess of water, and a plain paste soap is the result.

Antimonial Soap.—Prepared by dissolving 1 part of golden sulphuret of antimony in 2 parts of a saturated solution of caustic potash, to this add, of Castile soap in powder, 4 parts; triturate till the whole assumes a proper consistency.

Boracic Soap is readily made by (1) rubbing 1 oz. of powdered borax into 1 lb. of good Windsor or other soap. (2) Rub up equal parts of sodium borate and Voiry's paste soap.

Camphor Soap.—15 lb. white soap or soap-paste (cocoanut oil soap for preference), ½ oz. camphor, 2 drams caraway oil, 2 drams rosemary oil. Rub together and press into moulds. This soap is not coloured, but left white.

Camphor Savonette.—Spermaceti, 2 oz.; camphor, powdered with the addition of a little spirits, 1 oz.; white curd soap, melted with a little water, 24 oz.; amalgamate with a gentle heat and mould into balls.

Carbolic Acid is a material that serves all the purposes that tar will, without its disadvantages. It is a better material than tar, but is not odourless. A recipe is to melt 150 parts (by weight) of cocoanut oil soap and add 6 parts carbolic acid (crystals), 10 parts solution of alcohol, and 2 parts caustic potash. A little, say 1 part of oil of lemon may be added if desired. When well stirred it is ready for the moulds.

Disinfectant Soaps.—In few ways can disinfectants be so agreeably applied to the skin as when incorporated with soap. One of the last introduced, though probably one of the most efficacious, is thymol soap—first made by Ferris and Co., Bristol. Thymol is a non-poisonous (herein differing from carbolic acid) crystal, about eight times as powerful an antiseptic and disinfectant as carbolic acid, and is probably the only substance that combines disinfecting properties with a really pleasant smell, that of thyme. The best mode of incorporating thymol and phenol (i.e. carbolic acid) with soap is a trade secret; Morfit, however, states that carbolic soaps are best made by his process, using as a basis hot-pressed fat-acid cake, on account of the tendency of carbolic acid to soften the soap-paste.

Carbolic soaps are made in great variety and in large quantities by F. C. Calvert & Co., of Manchester, whose products contain specified definite quantities of carbolic acid of various qualities. Their "medical" soap contains 20 per cent. pure crystallised carbolic acid; their toilet and household soaps, 10 per cent.; their domestic soap 8 per cent.; and their "No. 5" or "scouring" soap, 4 per cent. liquid carbolic and cresylic acids. The comparative antiseptic power of soaps may be tested by adding equal weights, in solution, to equal weights of flour paste, and, after exposing these to the air under identical conditions, noting the day on which mould first appears on each. The so-called "coal-tar," or "sapo carbonis detergens" owes its disinfecting properties to a small quantity of carbolic acid in the coal tar.

It may be assumed as a pretty safe working rule, that almost any desired substance, whether soluble in water or not, can be mixed in this manner with soap, provided that (1) it is not too volatile at the lowest temperature at which the soap can be manipulated; (2) that if insoluble in water or alcohol it is in a state of very fine subdivision; (3) that it contains neither enough acid to decompose any portion of the soap, nor any mineral bases which would cause double decomposition with the sodium salts of fatty acids.

Thus Cleaver incorporates terebene, copper alum, or iron alum; Robottom adds borax or other borates; and others select camphoraceous products obtained by artificial oxidation of turpentine oil, such as "sanitas."

Ichthyol Soap has a demand on account of its reducing redness of the skin, and being beneficial in cases of eczema and rosacea. It is made up by rubbing 1 oz. (or any less quantity), of sodium sulphichthyyolate into 20 oz. of soap paste.

Insecticide Soap, for flowers and plants.—25 gal. water, 5 qt. methylated spirits, fusel oil (amylic alcohol) 3 pints, tobacco waste, 2 lb., soft soap 2 lb. Put the tobacco in a quart of water to boil for ½ hour, then strain. If the water is much reduced by boiling add more plain water to make the quart. Boil the soft soap in 25 gal. of water and when melted add the tobacco fluid. Allow to cool, then add the other two ingredients. Sufficient water can be added to double the whole bulk, and then it is ready for spraying or syringing.

Iodine Soap.—Make a solution of 1 part of iodide of potassium in 3 parts of water; to this add, of pounded Castile soap, 16 parts; melt in a porcelain vessel by the aid of a water bath.

Mercurial Soap.—(*a*) Dissolve in 1 lb. of alcohol 1 oz. of corrosive sublimate; filter this and rub up with sufficient Voiry's soap paste to absorb the whole (about 3 to 4 lb.).

(*b*) Beat into a homogeneous mass

in a Wedgwood mortar, Castile soap, 1 lb ; protochloride of mercury, ½ oz. dissolved in 4 oz. of alcohol.

Savol.—A medicinal soap, usually made up as a shaving-soap, as being a curative for a disease easily contracted from barbers' shop implements, has "salol" in its composition. This can be made by heating 2 lb. cocoanut oil and melting 4 lb. beef suet in this. Allow this to cool to 125° F. then add 3½ lb. of caustic soda lye (18°) and 10 oz. of caustic potash lye (24°), then stir over a gentle heat until the mass is homogeneous. This will probably be half an hour. While the mass is warm add ¼ lb. of finely-powdered salol and heat up to 115° F., this being the heat required to melt the antiseptic salol ; stir all the time. If it is required to perfume the soap, then, before the salol is put in, add a small quantity of oil of carraway, oil of bergamot, oil of lavender, oil of thyme, and essence of mirbane.

Sulphur Soap.—(*a*) This can be made up with any good paste soap to which is added one-tenth its weight, or any less quantity, of finely-powdered (flour) sulphur. Sulphur soap requires to be perfumed, as otherwise the sulphur gives the compound an objectionable odour. It may be made as follows : Rub to a smooth mass 2 lb. of fresh soap paste, Voiry's or a white curd or Castile soap, with 3½ oz. of flour sulphur, 4 fl. oz. of alcohol, and a few drops of attar of roses. To give the soap a good yellow colour the alcohol can be tinted with alkanet. A more simple recipe is to rub up 1 part by weight of flour sulphur with 10 parts of Voiry's soap paste, and then press to shape in moulds.

(*b*) Cut into small shavings white soap, 8 oz. ; beat up in a mortar with sublimated sulphur 2 oz. ; add 1 oz. of alcohol, to which may be added a few drops of any of the odoriferous essential oils ; beat the whole into a smooth paste and roll into balls.

Tar Soaps may not look nor smell nice, but they are usually effective. A recipe is (1) to beat together 2 parts of soap shavings, 1 part tar, and 2 parts liquor potassa. (2) Make a soap in the usual manner, the ingredients being 12 lb. cocoanut oil, 6 lb. tallow, 9 lb. soda lye (40° B.) and 3 lb. tar (juniper tar for preference). (3) A vaseline tar soap can be made by preparing a tar soap with 20 lb. cocoanut oil, 11 lb. soda lye (40° B.) and 3 lb. tar. Then melt 2 lb. yellow vaseline and stir it into the soap with ¾ pint of slightly warm water. (4) Another ordinary tar soap is made by simply working up together 18 lb. Voiry's paste soap with 2 lb. tar.

Palm-oil Soaps.—Palm oil is rarely used alone as a soap stock, but generally employed with an admixture of resin, and it then yields yellow soap ; for white soap, however, these are employed in the bleached state. For some kinds of soap, palm oil is saponified with 5 to 10 per cent. of cocoanut oil ; more is often used of the latter, and then filled soaps are obtained. Demi-palm is a soap consisting of equal parts of tallow and palm butter, to which is added a very small quantity of resin and coconut butter. 1. Palm oil, 300 lb. ; tallow, 200 lb. ; resin, 200 lb. 2. Tallow, 500 lb. ; palm oil, 300 lb. ; resin, 200 lb. 3. Palm oil, 450 lb. ; cocoanut oil, 50 lb. 4. Hog fat, 550 lb. ; palm oil, 150 lb. ; cocoanut oil, 50 lb. ; clarified resin, 50 lb. Palm oil may be made into soap exactly in the same way as tallow. If resin is incorporated, it is better to produce first the combination of the resin with the lye and mix the same with the finished palm oil soap. Soap made of bleached palm oil is perfectly white, and can scarcely be distinguished from tallow. Palm soap bleaches when exposed to the light.

Perfumed Soaps.—Perfuming is generally done when the paste is in the frame, as if added in the pan when the soap is hot, most of the essential oils would be volatilised. It is best to mix the colours and the perfumes together with some alcohol or glycerine, and stir well in the paste.

Almond Soap.—(1) The best quality

is usually white curd soap, with an addition of ⅙th to ⅐th of its weight of olive-oil soap, scented with essential oil of almonds in the proportion of about 1 oz. to each 4½ to 5 lb., or 1½ lb. to the cwt.; very fine. The addition of a little oil of cassia, say 4 or 5 oz. a cwt., improves it. Second and inferior articles are scented with the artificial oil of almonds, instead of the genuine oil. (2) Hard white soap, 28 lb.; essential oil of almonds, 4½ oz.; reduce the soap to small shavings, and melt with the aid of a little hot water, adding the essence gradually, and with constant stirring.

Bouquet Soap.—(1) White curd soap, finest, 17½ lb.; olive-oil soap, 2½ lb.; oil of bergamot, 1 oz.; oil of cassia, oil of cloves, oil of sassafras, oil of thyme, of each, 1½ dram; oil of neroli, 1 dram; ochre, brown, levigated, 2 oz.; proceed as for almond soap. It may be varied by substituting oil of lavender for the neroli. (2) White curd soap, 20 lb.; oil of bergamot, 2⅔ oz.; oil of cloves, ½ dram; oil of neroli. ½ dram; oil of sassafras, ⅓ dram; oil of thyme, ⅓ dram. Coloured with 2½ oz. brown ochre. (3) Good tallow soap, 30 lb.; essence of bergamot, 4 oz.; oils of cloves, sassafras, and thyme each 1 oz.; colour, brown ochre, 7 oz.

Cinnamon Soap.—(1) Usually a mixture of tallow and soaps, coloured with about ¾ lb. of yellow ochre, and scented with 1 oz. of oil of cinnamon, supported with a little oil of bergamot and sassafras, to each 7 lb. (2) Finest white curd soap, 6 lb.; palm-oil soap, 3½ lb.; cocoanut-oil soap, 1 lb.; oil of cinnamon, 1½ oz.; oil of bergamot, oil of sassafras, of each, ¼ oz.; lavender, 1 dram; levigated yellow ochre, ¼ lb. (3) Good tallow soap, 30 lb.; palm-oil soap, 20 lb.; essence of cinnamon, 7 oz.; essence of sassafras, 1¼ oz.: essence of bergamot, 1¼ oz.; colour, yellow ochre, 1 lb. Oil of cassia is often used instead of oil of cinnamon, and always in inferior qualities.

Flowers of Erin.—White curd soap, scented with oil of roses, 1 dram; spirits of violet, ½ fluid oz.; spirits of jasmine, ⅓ fluid oz.; spirits of patchouli, ¼ fluid oz.; spirits of vanilla, ¼ fluid oz. Tinged green or rose.

Glycerine Soap.—(1) Any mild toilet soap, with which about 1/25th to 1/20th of its weight of glycerine has been intimately mixed whilst in the liquid state. It is generally tinged of a red or rose colour, or orange yellow. Scent with oil of bergamot or rose geranium, supported with a little oil of cassia, or cassia supported with essential oil of almonds. (2) 40 lb. of tallow, 40 lb. of lard, and 20 lb. of cocoanut oil, are saponified with 45 lb. of soda lye and 5 lb. of potash lye of 40° Baumé, when the soap is to be made in the cold way. To the paste then add: pure glycerine, 6 lb.; oil of Portugal, ½ oz.; oil of bergamot, ⅓ oz.; bitter almond oil, 5 oz.; oil of vitivert, 3 oz. (3) One hundred parts of oleine of commerce, pour it either in a glass flask if the quantity is small, or for a larger quantity into an ordinary boiler, add 314 parts of glycerine, sp. gr. 1·12, heat to a temperature of 90° F., and then add 56 parts of an aqueous solution of caustic potassa, sp. gr. 1·34; stir the mixture well. Keep at rest for 24 hours.

Honey Soap.—Ordinary honey soap is the finest bright-coloured yellow resin soap, coloured by the addition of a little palm oil, or palm-oil soap, and scented with oil of rose geranium, or oil of ginger-grass, or with a little oil of bergamot or verbena. Some of the finer kinds are made of olive-oil soap and palm-oil soap, of each 1 part; white curd soap, 3; deepened in colour, whilst in a liquid state, with a little palm oil, or annatto, and scented with 1 to 1½ oz. of essential oils to each ½ lb., or 1 to 1½ lb. to each cwt.

Lavender Soap.—The basis of Windsor soap, scented with oil of lavender, 1 to 1½ fluid oz. per 7 lb., supported with a little oil of bergamot and the essences of musk and ambergris. It is often coloured with a little tincture of litmus, or corresponding mineral pigments.

Musk Soap.—(1) The basis is generally a good ox-suet or tallow soap; the scent, essence of musk or oil of musk, supported with a little of the oils of bergamot, cinnamon, and cloves. The quantity of the essence used depends on the intended fragrance of the product. The colouring matter is usually caramel. Tallow and palm-oil soap, to which add powder of cloves, roses, and gilliflowers, each 4 oz.; essence of bergamot and of musk, each 3¼ oz.; colour, brown ochre, 4 oz.

Orange-flower Soap.—(1) Like rose soap, but using pure neroli, supported with a dash of the essences of ambergris and Portugal, instead of otto of roses, as scent. The French orange-flower soap is scented with equal parts of neroli and geranium. (2) Tallow and palm-oil soap, to which add essence of orange flowers, 7½ oz.; ambergris, 7½ oz.; colour, chrome yellow, 8 oz.; red lead, 2 oz.

Primrose Soap.—This has usually a similar basis to honey soap, faintly scented with mixed oils similar to those used as cowslip perfume, and coloured pale yellow, or greenish yellow.

Rondoletia Soap.—The basis of cinnamon, rose or Windsor soap, scented with 1 to 1½ oz. of the mixed oils and essences used for essence of rondoletia, to each 7 lb. The colours are those used for bouquet, cinnamon, honey, or brown Windsor soap.

Rose Soap.—(1) Palm-oil soap, in shavings, 3 lb.; finest white curd soap, in shavings, 2 lb.; soft water, ¼ pint. Melt together in a bright copper pan, set in a water bath. Add levigated vermilion, ¼ oz.; and when the mixture has cooled a little, stir in finest otto of roses, 2 drams; oil of bergamot, 1½ dram; oil of cinnamon, oil of cloves, of each, ¾ dram; oil of rose geranium, ½ dram. Mix well, and pour the mass into an open-bottomed wooden frame, set on a polished marble slab. Sometimes it is coloured with tincture of dragon's blood, or of archil, instead of with vermilion. (2) White curd soap, 20 lb.; essence of rose, 1⅓ oz.; oil of cloves, ½ dram; oil of cinnamon, ⅓ dram; oil of bergamot, 1 dram; oil of neroli, ⅓ dram; coloured with 2 oz. vermilion. (3) Olive-oil soap, 30 lb.; good tallow soap, 20 lb.; finely ground vermilion, 1½ oz.; essence of rose, 3 oz.; essence of cloves, 1 oz.; essence of cinnamon, 1 oz.; essence of bergamot, 2¼ oz. The hard soaps are to be kept at 212° F. for an hour, with 5 lb. of water, in an untinned copper pan, the vermilion then added, and when taken off the fire, the essences mixed well with it, by stirring them together. This is a very perfect soap, possessing a delicious fragrance, a beautiful roseate hue, and the softest detergent properties, which keeping cannot impair.

Violet Soap.—(1) Any white toilet soap strongly scented with essence of orris root, either coloured, or not, with tincture of litmus, or a little levigated smalts, ultramarine, or indigo. (2) White curd soap, 3 lb.; olive-oil soap, 1 lb.; palm-oil soap, 3 lb.; melted together, and further scented with a little essence of orris-root, which is best added cold; and coloured, or not, at will. Very fragrant, but it does not take colour very well.

Windsor Soap.—1. White. The best is a mixture of olive oil, 1 part; ox-suet, or tallow, 8 or 9, saponified with a lye of caustic soda, and scented after removal from the boiler. The ordinary is curd soap, scented, whilst semi-liquid, with oil of carraway, supported with a little oil of bergamot, lavender, or origanum. To the finer qualities a little oil of cassia, or of almonds, or of the essence of musk and ambergris, is also added. The usual proportion of the mixed oils for good qualities, is 1½ lb. per cwt., and 2 lb., at the least, for the finer ones, exclusive of the alcohol essences, if they are employed. 2. Brown. Originally this was the white variety that had become yellow and brown by age. It now only differs from the white in being coloured with a little caramel, with umber, or brown ochre. 3. Nine parts of good ox-tallow and 1 of olive oil, scented with oil of carraway, oil of lavender, and oil of rosemary, in the following proportions: Hard curd soap, 100 oz.; oil of carraway, 1 oz.; oil of lavender, ¼ oz.; oil of rosemary, ¼ oz.

Polishing Soaps.—(1) Stir into 25 lb. of liquid cocoanut oil soap, 2 lb. of tripoli and 1 lb. each of alum, tartaric acid and white-lead.

(2) Stir into 25 lb. of liquid cocoanut oil soap, 5 lb. of jeweller's rouge, and 1 lb. of ammonium carbonate.

(3) Mix 25 lb. of liquid cocoanut oil soap with 4 to 5 lb. of calcined oxalate of iron.

(4) Stir together 24 lb. of cocoanut oil with 12 lb. of lye of 38° to 40°, and when the mass appears bright add 3 lb. of jeweller's rouge, mixed with 3 lb. of water, and, finally, 1 oz. 2 drams of spirit of sal-ammoniac.

(5) Reduce 5½ lb. of cocoanut oil soap to fine shavings, add some water and melt. To the melted soap add then, with vigorous stirring, 6 oz. 5 drams of chalk, 3 oz. 2 drams each of alum, tartaric acid and dry white lead.

English Silver Soap.—This soap, which may be used for giving silver articles a beautiful lustre by brushing, is prepared as follows: Dissolve 2 parts of Castile (pure olive oil) soap in 2 parts of soft water over a fire, and stir into the mass 6 parts of whiting. The soap is put into moulds and allowed to cool.

English Rose-colour Silver Soap.—This soap is prepared in the same manner as the preceding, but instead of 6 parts of whiting, the following ingredients are stirred into the melted mass: Fine white tripoli 2 parts, pulverised chalk 3 parts, and jeweller's rouge 1 part. Before pouring the soap into moulds it is perfumed with a few drops of oil of lavender, giving it an odour which contributes towards its ready sale.

Powders.—These always contain, besides powdered dried soap, a large percentage of sodium carbonate, generally in the form of dried soda crystals. They may be prepared in several ways, thus:—

(*a*) Anhydrous sodium carbonate or soda ash is added to a "clear-boiled" soap-paste, and after thorough mixing, the somewhat stiff material is drawn off into cooling frames. The cold and hard soap thus obtained is then finely ground.

(*b*) Soda crystals and soap are melted together and then treated in the above manner; but this plan is advantageous only when soap scraps can be had.

A suitable apparatus for conducting the operation consists of a wrought-iron vessel with a strong agitator contained in an interior cast-iron vessel, which can be cooled by water circulated in the outer vessel. The liquid soap is cooled while the soda ash is slowly added and completely dissolved. During the grinding process care must be taken not to overheat and thus soften the product.

The composition of soap powders varies considerably. Only a small proportion of resin soap can be used, as such soap is sticky, and cannot be powdered. Olein soap may be used with advantage, and the olein may be saponified with sodium carbonate instead of the more expensive caustic lyes.

As a small quantity of free chlorine is not objectionable in soap powders, dark coloured materials such as bone fat, fish oils, etc., may be used for making the soap, with the addition of a small quantity of bleaching powder.

To some soap powders, 2 to 5 per cent. of sodium silicate is added.

A good washing powder should contain 30–35 per cent. fatty acids, 30–35 per cent. sodium carbonate, 30–40 per cent. water.

The inferior powders, containing only 5–10 per cent. fatty acids, should not be used for the laundry; they are only serviceable for scrubbing purposes.

There is a soap powder in the market prepared by treating linseed with caustic soda directly. This soap contains certain impurities derived from the seeds, which lather freely, and thus, when the powder is used, gives the impression of more genuine soap being contained in the powder than is actually the case.

(*c*) *Soap Powder or "Soap Extract."*—Yellow soap in shavings 12 lb., palm oil 2 lb., soda crystals 6 lb., pearl ash 3 lb., sulphate of soda 3 lb. Mix together without water, then put to dry. When dry grind to a medium powder, not too fine.

For washing printers' blocks and types, a powder is recommended containing only a small quantity of combined fatty acids, but 10–15 per cent. caustic soda.

The so-called "bleaching soda" consists of 80 parts soda crystals and 20 parts soda silicate.

The composition of some American washing powders was found to be—

	a	*b*	*c*	*d*
Sodium carbonate	45·2	26·9	49·2	46·6
Fatty acids . .	26·4	44·0	25·6	25·7
Combined soda .	3·1	3·4	3·5	2·6
Water . . .	23·7	8·8	19·1	24·9
Fine sand . .	..	16·3	..	..

They are therefore mixtures of dried soap and washing soda, and may be used in conjunction with soap to soften hard water, but if used alone must be injurious to textile fabrics. Borax might be added, instead of the soda, apparently with advantage.

Pumice-stone Soaps.—These are produced by the cold process. One method is to melt 400 parts (by weight) of cocoanut oil and 100 parts of cotton oil, and stir in 240 parts of caustic soda lye (38° B.) and 10 parts of caustic potash lye (30° B.), both the lyes having a temperature of from 32° C. to 35° C. (89·68° F. to 95° F.). Sift in 250 parts of pumice powder, and to scent the soap mix in 1½ part of cassia oil, 1 part of rosemary oil, ½ part of lavender oil, ½ part of safrol, and $\frac{1}{10}$ part of clove oil.

Resin Soap.—Place 80 gal. of ley into a kettle of sufficient capacity, first boil the contents, and then throw resin in at intervals of 5 or 6 minutes, and in portions of 15 to 20 lb., until 1320 lb. have been added. The resin must be previously well pulverised, and while one workman is occupied with throwing it in, another should be constantly engaged in stirring it, as the mixture easily ascends. The heat must not be too rapidly increased, nor is it necessary that it should boil all the time, but keep the temperature near the boiling point. It is absolutely requisite to keep stirring the paste all the time. Saponification will be finished in 2 hours, and then the mixture, with the fat, is converted into soap as above described.

Shaving Soaps. *Paste*—1. White soft soap, 4 oz.; finest honey soap, 2 oz.; olive oil, 1 oz.; water 1 or 2 tablespoonfuls; carbonate of soda, 1 dram. Melt together and form a paste, adding a little proof-spirit and scent at will. Some melt with the soap about 1 dram of spermaceti. Produces a good lather with either hot or cold water, which dries slowly on the face. 2. Hard soap in small shavings, 2 oz.; best soft soap, 6 oz.; melt by the aid of a water bath; add, on cooling, oil of cloves, 1 dram; tincture of ambergris, 20 drops.

Soap.—It will be understood that a shaving soap should be mild, and that it should not only lather well, but the lather should be as permanent as possible. Ordinary soaps are too alkaline to be called mild, and the lather is not permanent enough. A good shaving soap can be made in the "cold" way as follows:—Mix together 2 lb. cocoanut oil, 6 lb. lard, 3 lb. caustic soda lye (35° B), and 1 lb. caustic potash lye (35° B.). Heat all to 120° F., and when well mixed allow to set. All shaving soaps are perfumed, the chief ingredients used being oil of lavender, oil of bergamot, oil of peppermint and oil of bitter almonds. What has been known as the Military Shaving Soap has for perfume oil of lavender 3 parts, oil of peppermint 1 part, oil of bergamot 4 parts, oil of thyme 2 parts, oil of cinnamon 2 parts, and oil kummel 3 parts.

Cream.—Take white, soft, lard potash soap, recent, but moderately firm, and beat in small portions at a time, in a marble mortar, until it forms a white homogeneous mass; add sufficient essential oil of almonds, supported with a little oil of bergamot, or of cassia, put in during the pounding.

Essence or Fluid.—1. White hard soap, in shavings, ¼ lb.; rectified spirit, 1 pint; water, ¼ pint; perfume to taste. Put them into a strong bottle, cork tightly, set it in warm water for a short time, and occasionally agitate it briskly until solution is complete. After standing, pour off the clean portion from the dregs into clean bottles for use, and at once closely cork them. If the solution is not sufficiently transparent, a little rectified spirit should be added to it before decantation; a little proof-spirit may be added if it is desired to render it thinner. If much essential oil is used to perfume it, the transparency of the product will be lessened. 2. White soft soap, ¼ lb.; liquor of potassa, 2 fluid drams; rectified spirit, 1 pint. Perfume to taste. Proceed as before. The product of both is excellent. By rubbing two or three drops on the skin, and applying the shaving-brush, previously dipped in water, a good lather is produced. The choice of perfume is a matter of taste, 15 to 20 drops of essence of musk or ambergris, 1 fluid dram of any of the ordinary fragrant essences, or 12 to 15 drops of essential oil, simple or mixed, to a pint, are sufficient for the purpose.

Soap Balls.—These are usually made of one or other of the toilet soaps with the addition of a little starch; sometimes sand is used in place of the starch.

Sand Soap.—Under this heading occur a number of soaps in which it is sought to unite the chemical action of soap with the mechanical aid afforded by sand in scouring. According to C. Roth ('Seifenseider Zeitung,' Nov. 21, 1884), as much as 70 per cent. of clean sand or powdered quartz is sometimes mixed with soap paste, and experiments showed that such soap had no disagreeable effect on the hands when used as a detergent. In a similar way, soap is made the vehicle of many substances to be applied to the skin, medicinally or otherwise, or in any cleansing process. All these should be incorporated with "neat" soaps, freshly made or remelted, at as low a temperature as possible. Some form of soap is not unfrequently the basis of polishing pastes.

It is obvious that many abrasive substances besides sand can be incorporated in soap, such as fuller's earth, pumice, brickdust, emery, etc., in all proportions up to the limit of cohesion of the mass. Even some toilet soaps are so prepared for application to the teeth, substituting precipitated chalk, cuttlefish bone, etc., for the commoner forms of abrasive material.

Sand Ball.—Fine old yellow soap, 2 parts; silver sand, 1 part; scent to taste; melt the soap and mix in the sand, afterwards adding the scent and making into balls.

Soap Bubbles, Mixture for.—Fill a clean stoppered bottle three-quarters full of water (which should be distilled, or very clean rainwater). Add one-fortieth part of its weight of oleate of soda, which will probably float on the water. Leave it for a day, when the oleate of soda will be dissolved. Nearly fill up the bottle with Price's glycerine and shake well, or pour it into another clean bottle and back again several times. Leave the stoppered bottle for about a week in a dark place. Then, with a syphon, draw off the clear liquid which will have collected at the top. Add one or two drops of strong liquid ammonia to every pint of the liquid. Then carefully keep it in a stoppered bottle in a dark place. Do not get out this stock bottle every time a bubble is to be blown, but have a small working bottle. Never put any back into the stock. In making the liquid, do not warm or filter it, or it will be spoiled. Be most careful to expose the liquid to the air as little as possible. (Boys.)

Soft Soap.—(*a*) For the manufacture of soft soaps, hempseed oil, linseed oil, poppy oil, rapeseed, colza, whale, and seal oils are used. Saponification is commenced with a lye of 9° to 11° B., and the contents of the kettle kept boiling, until the paste becomes of sufficient consistency to draw threads out of the substance. It then undergoes the process of clear-boiling, for which purpose a lye of 25° B. should be used, stirring all the time. When the paste does not sink any more—first it ascends—boils quietly and shows the formation of scales, it may be considered finished. The barrels in which it is to be offered to the trade should be immediately filled. The quality of soft soaps is estimated according to their consistency. Green soap was formerly made of linseed oil. It is now, however, made principally of whale oils, but as they have a yellow colour, manufacturers mix the soaps made of the whale oils with finely-powdered indigo, or the indigo-sulphate of lime, which is prepared by dissolving indigo in sulphuric acid, diluting it with water, and saturating the whole with lime-milk. Black soft soap is made by adding to the soap a mixture of a solution of copperas and logwood or gallnuts.

(*b*) In the manufacture of either smoothed or grained soft soap, the chief fat used is linseed oil. This, if it is pure and of good quality, makes a fine transparent soap, of lasting quality and allowing more filling than other oils. If properly made of linseed-oil soft soaps will stand cold best of any, and even if they have become somewhat turbid during exceptionally sharp weather, they recover their appearance as soon as it gets warmer. The seed yields from 26 to 30 per cent. of the oil by pressure, and the oil will keep a long time without becoming rancid or deteriorating in any way. Besides linseed oil, cottonseed and earthnut oil are much used in soft soap manufacture, and for the cheapest and most filled kinds, oil sediments full of stearine are often employed. These answer in the summer, but are apt to cause trouble by efflorescing in cold weather. Linseed-oil soft soaps are principally used for household purposes, and are of many varieties. Unfilled natural-grain soft soap is the best, and is prepared from 2 parts of pale linseed oil and 1 part of good tallow. If the evaporation is carried on till nearly all the froth has disappeared, the soap will be more durable, and faster graining than if the action is pushed farther. For technical purposes oleine gives better results than linseed oil, and produces more soap, weight for weight, but the oleine must not have undergone decomposition. Distilled oleine is often found to have been partially decomposed in the distillation. For some purposes, too, tallow-oleine grain soap is not soluble enough. In washing fleeces, for instance, the hard grain soap often lodges undissolved in the wool, especially if old soap has been used. This is a waste of soap, and hinders the subsequent dyeing operations. For such use, the soap is best made from oleine alone; or a hard potash soap with plenty of carbonate in it may be used. Good soaps for the purpose can also be got from mixtures of oleine with its own weight of palm oil, but if these soaps are kept too long in stock they lose in solubility. A good recipe for a natural-grain textile soap is oleine, 5 lb.; cottonseed oil, 4½ lb.; hard fat, 6 lb.; bleached palm oil, 1½ lb.; and raw palm oil, 2 lb. A few pounds of tallow not containing too much stearine can also be worked in, and the hard fat mentioned can be replaced by bleached palm oil. Good Lagos oil gives a fine round grain. Such soaps can be filled easily to some extent, and in winter best with 15° B. potash, in summer with 13° B. potassium chloride. It is most important to attend to the composition of the lye. In using 50° B. potash lye, it should, in the colder season of the year, be mixed with a quarter of its weight of 97 to 98 per cent. carbonate of potash in solution, so as to make a 25° B. lye. As with all natural-grain soaps, these soft soaps must be got as nearly neutral as possible. If this and the evaporation are properly seen to, the soap will dissolve easily and the grain will not be too solid. The washing power of a soap depends upon its solubility and lathering power. As potash soaps containing resin are the most soluble, the latter substance increases the cleansing power. Most soft soaps, too, contain an excess of alkali, especially those filled with meal, and this alkali still further increases the washing capabilities of the soap. Linseed-oil soft soaps are made quite unfilled, or containing a high percentage of filling. To get the soap as transparent and as light in colour as possible, even the palest oil sometimes is bleached, and in summer cottonseed oil is used with it. The bleaching is usually done with a 30° B. potash lye not too caustic. When a strong lye is used, the dark precipitate which contains the colouring matter, and also the product of the saponification of the free fatty acid originally present, can be utilised in manufacturing low-grade soaps. 100 lb. of linseed oil can be bleached with 6 lb. to 7 lb. of the above lye, the lye being run whilst warm into the oil in a thin stream, and being well crutched into it for half an hour. By crutching is meant the stirring together of the ingredients by means of a perforated piece of wood or iron attached to a pole. If the oil is very pale, 5 lb. of lye will suffice for the bleaching; but in any case bleached oil wants a stronger lye for saponification than unbleached. With the latter the lye should not contain much carbonate, and should not exceed 18° B. in strength. Later, stronger lye is added to prevent the soap getting too thick. For the saponification of 100 lb. of oils, 150 lb. of 25° B. potash lye are used generally. To 100 lb. of oil in a pan, 25 lb. of 20° B. lye and 10 lb. of water are added. To ensure quicker union, about 5 lb. of resin should also be added. Heat all up and crutch repeatedly; when an emulsion is formed, boil it in the pan. Now gradually add the rest of the lye, boiling up after each addition. Finally, evaporate over not too strong a fire. In winter it is better not to use soda lye, but in summer soda to the amount of 30 per cent. of the fat can replace part of the potash. The soda is put in altogether, after about one-third of the potash lye is in the pan. The resin is often added at the end, and if the soap is rather alkaline, usually makes it about right. A well-finished soap must be thick in the sample glass, should show a good flower, and be quite clear when cold. When soda is used, less evaporation is needed. Summer soft soaps must not show so much flower as a winter-made soap, and should keep better. There may be rather more carbonate in the lye if the soap is not to be filled, and carbonate of potash can be added. The above process gives a very pale amber soap. For filling, the best substance is 13° B. solution of potassium chloride, which is crutched in when the finished soap has partly cooled. In adjusting or fitting a soft soap, the use of carbonated alkali is essential. All soft soaps boil tough before they are properly adjusted. When right they break off rather short from the spatula. A piece as big as a half-crown should be set at the edges, but should yield liquid soap on pressure with the finger in the middle. Subsequent filling will not do away with the bad results of careless fitting, and in any case the soap will turn rancid if deficient in alkali, and brittle and unsatisfactory if there is too much. The following is a good recipe for a well-filled soap. Linseed oil, 100 lb.; resin, 20 lb.; meal, 52 lb.; potash (15° B.), 58 lb.; potassium chloride (23° B.), 20 lb.; and waterglass, 15 lb. Besides this, the addition of from 56 lb. to 58 lb. of fitting lye of 30° B. will be made necessary by the filling. It is often asserted that more filling is wanted in summer than in winter. This is only correct when soda lye is not used. With filled soaps, excess of lye is to be particularly avoided. If the soap is to be made grain, very fine indigo is ground to the finest possible powder, boiled in weak lye, and added to the pan at the very last, when the soap is just going off the boil. The colour is better and more uniform if the indigo is ground up with its own weight of fuming sulphuric acid, and then left to stand for several days in a warm place. The solution is then stirred up with soda crystals until fairly neutralised. In this way the colour is made very soluble in the soap, and is crutched into it very easily, giving an even-coloured product. About 1 oz. of indigo is used for every 63 lb. of soap. Formerly hemp oil was used always for green soft soaps. This oil resembles linseed in its properties, but has a fine green colour. It gives a good leaf-green soap, but the high price of hemp oil precludes its extensive employment. ('Soapmaker and Perfumer.')

Tallow Soaps.—To saponify 1000 lbs. of fat, commence by putting the tallow into the boiler, and melt it with a slow heat, add 70 to 80 gal. of lye of 10° to 12° B., stir well, and keep a gentle fire for several hours. Should part of the fat separate from the mass, which is often the case, an oily liquid will be observed floating on the top. Then add, gradually, 35 to 40 gal. of lye of 15° to 18° B. By this addition the whole contents will form a homogeneous mass of a greyish-white colour. In order to establish the necessary consistency to the paste, boil gently for several hours, adding every hour 6 to 7 gal. of lye of 20° B. The time necessary for the first operation is from 10 to 12 hours for 1000 lb. of fat. After this, pass to the cutting process, and operate as before described. It is essential that care be taken to stir the ingredients well while adding the salt. When the separation has taken place, leave altogether quiet for several hours, and then draw off the coloured under-lye; 90 gal. of lye of 25° should then be added; increase the heat, there being strong lye at the bottom of the pan, which preserves the soap from burning. Boil this mass from 10 to 12 hours, adding every hour 5 gal. of lye of 25°; 4 or 5 hours' boiling will often be sufficient to saturate the soap. This being accomplished, extinguish the fire, leave it quiet for an hour, and then draw off the under-lye. It will measure from 25° to 30° B. To complete the process, add about 50 gal. of lye of 4° B. Let this boil gently for 1½ to 2 hours, stirring from time to time with the crutch, and finally extinguish the fire and cover the pan. The soap will separate from the lye, and rise to the top. After 5 to 6 hours, while yet in a liquid state, pour it in the frames, taking due care that no lye is mixed with it. In the frames it should be well stirred for some time. For neutralising the disagreeable tallow odour, 1 to 2 oz. of a well-scented essential oil should be added to 100 lb. of the soap, and after 7 to 8 days it may be cut. 100 lb. of tallow will yield about 170 lb. of soap.

Tallow Resin Soaps.—Resin, incorporated with a soap, to a certain amount, will make it more soluble and detersive. The lighter the resin the more it is valued; 15 per cent. of resin with 85 per cent. of tallow is allowable, but beyond that limit the soap loses in colour, in firmness, and quality. Even for the cheapest article the quantity of resin should not exceed 33 per cent., otherwise the soap will be soft, and unprofitable to the consumer. The resin can be saponified with alkali; 12 gal. of lye of 30° B. are needed for every 100 lb. of resin. Some soapmakers melt it with the fat at the commencement of the boiling for soap, but a much better product is obtained by first producing a tallow soap, and afterwards mixing the resin soap with it, made in the meantime in a special kettle. Both mixtures have to be stirred and beaten thoroughly for half an hour, and the whole passed through a sieve before they are filled into the frames, and therein well stirred and crutched. Some palm oil, when saponified with the tallow, very much improves the appearance of the soap.

Transparent Soaps are prepared by dissolving well-dried soaps in alcohol; but all kinds of soap cannot, with equal facility, be thus transformed. It is difficult to work up into a solid consistency soaps made of olive oil, when treated with alcohol, and they invariably assume the opaque form. A good suet soap should always be preferred, and resin tallow soaps readily yield yellow soaps of a remarkable transparency. The first step necessary for making these soaps transparent is to cut them into very thin ribbons, which can be done with a knife, or with a soap-mill. The soap is extended on strong paper, and exposed to the air and sun until it is thoroughly dried. It is then pulverised in a marble mortar, and passed through a fine sieve. The powder thus obtained is directly dissolved in strong boiling alcohol. While the soap is liquid, the colours and perfumes are incorporated with it. Three and a half gallons of alcohol of the specific gravity of 0·849 are generally used to 50 lb. of soap. A still, heated by steam or hot water, is used for this operation, as a considerable quantity of alcohol would be lost in a common heating pan, and the direct application of fire would destroy the beauty and transparency of the soap.

Miscellaneous Receipts. — *Purifying and Bleaching Bone Fat for Soap Making.*—Bone fat is obtained, by steam under pressure, from bones, and is often used in soap making for brown, mottled, and manufacturer's soaps. The soaps made therefrom are deficient in firmness and body, unless some other fat is used in conjunction with it. Before bone fat, bone oil, or bone tallow, as it is indiscriminately called, can be used, it is required to be bleached somewhat, so as to remove its brown colour as much as possible. The amount of caustic soda required to saponify it is 13·87 per cent., and that of caustic potash 19·42 per cent. The fat contains water, from a trace to 2 per cent., also about a ½ per cent., of mineral matter, and many impurities that have to be removed before it can be used for soap making. To remove the impurities dissolve 2¼ lb. of chloride of zinc (this is a very poisonous substance to handle), then boil 100 lb. of the bone fat from 6 to 8 hours in the solution; afterward as a further purification raise the temperature of the fat to 167° F., then put in 2 lb. of soda solution of 34° to 35° B., and 1 lb. of sodium chloride (previously dissolved in water) to every 100 lb. of the bone fat. Keep stirring the fat while adding these ingredients, and then let the mixture rest quietly for some time. Afterwards pour off the clear fat into wooden vats and allow it to cool down to 105° F.

To bleach this purified fat make a solution of 8 oz. of bi-chromate of potash in boiling water (cold water will not dissolve such a large quantity of the salt, and even at this temperature the salt will crystallise on cooling a few degrees), mix this with 32 oz. by weight of fuming hydrochloric acid, then pour this mixture into the purified oil slowly at 105° F., constantly stirring, and continue to do so until the greenish colour changes into a yellowish one, then wash the fat by means of water, using a sprinkler to do this. Two per cent. of permanganate of potash followed by a 2 per cent. solution of oxalic acid, renders the colour brighter. Wash the bleached fat so as to remove all traces of the oxalic acid.

Recovering Glycerine from Soap Boiler's Lye.—Glycerine is obtained as a lye product in making soap. For many years the lyes were thrown away as waste, but now considerable quantities of glycerine are recovered.

When a metallic salt or one of the alkalies, as caustic soda, is added to tallow, a stearite of the metal (common soap is stearite of sodium) is formed, whereby the glycerine is eliminated. This valuable lye product is obtained in the waste lye, and has formed the subject of several patents, but there is still much room for improvement. As these processes are all patented they can be worked only under a royalty, and therefore details cannot be given, but the following method or process is sufficient to enable any one to undertake the recovery of the glycerine from the spent lye.

Draw the lye off from the soap-pans, this contains a large quantity of water, some salt and soap, and a small quantity of glycerine, and the great trouble is to concentrate the lye so that the large quantity of water is eliminated, sometimes 10 to 12 days being occupied in doing this. The soap and salt are easily removed.

To remove the soap run the lye into a series of tanks alternating in size, step-like, so that as the first, which should be the largest, becomes full, the liquor will flow into the second, from that into the third, and so on; by this arrangement the resinous and albuminous matters will settle, and the soap still contained in the lyes will float on the surface, from which it is removed by skimming.

After thus freeing the lye of the solid impurities, convey the purified lye to the glycerine recovering department (wooden troughs or pipes may be used to do this,) and after concentrating by heating it in a steam jacketed boiler, and allowing it to cool somewhat, ladle out the solid salt that separates, and afterwards concentrate the lye by allowing it to flow into a tank, but before doing so let the fluid come into contact with a hot blast of air or super-heated steam, whereby the crude discoloured glycerine is obtained. This is further purified by heating with animal charcoal to decolorize it, then distilling several times in copper stills with super-heated steam. The chief points to attend to are the neutralising and concentrating the lye as much as possible, then separating the salts and solid matter, and afterwards to concentrate the purified lye and mix this fluid with oleic acid, oil, tallow or lard. The mixture is then heated to 338° F. in a still, by steam, and the heat gradually raised to 372° F. Stir the liquor whilst being heated, and allow the aqueous vapour to escape; and when thus concentrated, saponify the liquid with lime to eliminate the glycerine; water is at the same time expelled, but this is removed from the glycerine by evaporating the mixture.

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SODA.

(*See also* ALKALIMETRY, *and* CLEANSING *and* SCOURING.)

IT is not within the province of Workshop Receipts to treat of the manufacture of soda, for it requires an enormous plant and outlay, with considerable skill and the employment of skilled labour, but there are a number of useful purposes that soda is put to which may be described. As a cleaning agent its powers are well known, and for various uses it is probably a substance mentioned in different parts of these volumes more often than any other. These, however, need not be repeated. The basis of soda is the metal, sodium, the salts of which are most abundantly distributed. Common salt is chloride of sodium, while washing soda is crystallised sodium carbonate; the nitrate, carbonate, and sulphate also form considerable geological deposits, and the silicate occurs in many minerals. The metal, like potassium, can be prepared by electrolysis, but less easily. A second method is by decomposing caustic soda with metallic iron at a white heat; and a third, which is that adopted on an industrial scale, consists in igniting a mixture of soda carbonate and charcoal, the operation giving rise to no risk of explosions as is the case with potassium. In practice, 66 lb. common soda-ash is well ground up with 28½ lb. slack or small coal and 6½ lb. chalk, and the mixture is put into an iron cylinder 3 ft. 9 in. long, and 5 in. in diameter, coated with fire-clay; this is introduced into a reverberatory furnace, and heated to whiteness; its ends are closed by iron plates, one being traversed by a 1-in. iron gas-pipe, through which the gases and sodium vapour escape, the latter being condensed by passage through a cooling receiver and falling into a dry iron pot placed beneath, while the escaping carbon monoxide burns with a yellow flame and forms no explosive compound. The operation is made nearly continuous by arranging the cylinders in sets in the furnace, and discharging and recharging them in turn. The actual product is only about one-third of the theoretical yield, owing to losses incurred by part being volatilised and burned, part adhering to the receiver, and part being imperfectly reduced. The metal thus obtained is pure enough for general use, and only needs to be remelted and cast into rods 1 ft. long and 1 in. thick; these will keep in dry air in closed vessels for a long time, becoming covered with a thin coating of oxide which preserves them from further attack; but small pieces should be stored under petroleum.

"W. P. Thompson has proposed a novel method of preparing all the alkali metals which, if successful, would greatly reduce their cost. The reducing agent used is liquid iron, either alone or in conjunction with hydrogen or carbon, the operation being performed in an apparatus resembling a Bessemer converter. In the preparation of sodium, iron mixed with an equal quantity of carbon is treated with caustic soda in the converter, and the sodium said to be formed under these circumstances is simply distilled off." ('Analyst.') This does not appear to offer much advantage over Gay-Lussac and Thénard's process, already mentioned (the second method spoken of).

Metallic sodium has a silver-white colour and lustre; it is hard at − 4° F. (− 20° C.), very ductile at 32° F. (0° C.), of a waxy consistence at ordinary temperatures, semi-fluid at 122° F. (50° C.), and melts into a mercury-like liquid at 204° F. (95½° C.); it oxidises in moist air, volatilises at a red heat, and has a sp. gr. of 0·9735 at 56° F. (13½° C.); in the conductivity of heat and electricity it ranks after gold, and in electro-positiveness after silver, copper and gold; it forms with potassium an alloy which remains liquid below 32° F. (0° C.), if more than 16 parts potassium are combined with 10 of sodium. It is commercially employed as a reducing agent in the preparation of other metals (aluminium, boron, magnesium); and its amalgam with mercury is largely used in place of mercury alone for catching fine and dirty gold in the apparatus employed for treating auriferous ores.

Carbonate of Soda.—In working to chemical recipes it should be noted that when carbonate of soda is mentioned, it does not often mean washing soda. The latter, when specified, is given its own name, or may be mentioned as soda crystals or sal-soda; for although it certainly is carbonate of soda, the crystals are chiefly made up of water—the water of crystallisation. 100 parts of washing soda contain 37 parts of carbonate of soda and 63 parts of water. Pure dry carbonate of soda has the formula (Na_2CO_3), while washing soda is $Na_2CO_310H_2O$. It follows that in effectiveness 37 parts of the pure carbonate are equal to 100 parts of the washing crystals, and calculating on this basis either can be used in working out a recipe.

Bicarbonate of Soda.—This is carbonate of soda converted to bicarbonate by passing carbonic acid over it until it will absorb no more. It can be very cheaply produced. This is one of the chief ingredients in baking-powders, seltzogene powders, etc.

Sulphate of Soda or Glauber's Salt.—The making of this requires large plant and an experienced staff, but the following is a brief outline of Leblanc's process. Common salt (chloride of sodium) in a moderately fine state is fed into an iron still, and the necessary proportion of sulphuric acid (oil of vitriol) is run into it. A chemical action immediately takes place, and as soon as this ceases heat is applied to continue it as far as possible. The result of this is the evolution of hydrochloric acid vapour, while the remaining mass is neutral sulphate of soda. As the hydrochloric acid produced is a valuable product, this is recovered by causing the vapours to pass up several towers which are cooled with running water. Here the acid is condensed and collected. The rough soda sulphate when taken out of the still is first dissolved in water, then crystallised out.

Caustic Soda (Sodium Hydrate). This is a substance requiring large plant and an experienced staff for its production on a commercial scale. The process resembles that of sulphate of soda right up to the production of the raw soda cake and hydrochloric acid. The soda cake, after being broken up, is mixed with limestone and coal and heated in a reverberating furnace, the production being an impure carbonate of soda. This is made into a fluid with water, then subjected to heat and evaporated to a dry condition, the result being what is called soda ash. This latter material is again dissolved in water, and a certain amount of slaked lime added, which on boiling, produces caustic soda, with carbonate of lime as a by-product that could be dispensed with. The liquid caustic soda is then heated to a dry state, the heat being continued until the residue is fused. This fused mass is then poured into pans to cool, and makes the fibrous cakes of caustic soda as usually obtained. A small quantity could be made by first melting some carbonate of soda in water, adding a thin solution of lime, and boiling together. The result would be a solution of caustic soda.

Stannate of Soda.—Take 4 parts of caustic soda and 2 parts of powdered native oxide of tin (tinstone) and fuse them together. When melted, add a small quantity of hot water, then allow to settle and decant off the top clear liquid. Heating and evaporation will reduce this liquid to fluid stannate, while further evaporation will cause crystallisation. The crystals can be separated from the remaining liquid (when cool), and after lightly washing are dried. The remaining liquid material can be evaporated to dryness, and this with the insoluble part, from which the liquid was decanted, can be added to the next lot made so as to prevent waste.

Silicate of Soda or Water-Glass.—Boil together, under pressure, ground flint and a strong solution of caustic soda. Or heat together in reverberatory furnace 100 parts soda ash, 180 parts white sand, and 3 parts charcoal. This substance resembles glass, but is soluble in water. As a rule it is not obtained in a hard mass, but in a thick solution like syrup.

Testing Soda Solution for Boilers.—To test the strength of a soda solution a salinometer is used, this being a simple instrument (like a milk tester) which sinks more or less in a liquid according to its density or powers of buoyancy. Thus, if a solution of 50° to 54° density is required, the right strength can be tested by floating the instrument in the fluid, and if it sinks to a mark between 50° and 54°, it would be correct. If it sinks too low, i.e., to a figure below 50°, then more soda is added; while if it does not sink to 54° the solution is too strong and more water is needed. If a large quantity is required, the whole need not be made and tested in this way. It will be sufficient if a certain quantity of water—1 gal. or 5 gal.—be taken, and the quantity of soda needed to make this of right strength accurately noted. This will give the weight of soda required per gal. for the whole bulk of water to be treated.

The Use of Washing Soda in Mixing Cement.—The effect of using washing soda in mixing Portland cement is to make its preliminary setting very rapid. As an agent to cause cement to harden quickly, soda serves a certain useful purpose, but beyond this its presence may prove harmful. It will be seen that it amounts to mixing a soluble substance with the cement, one that can be washed out by rain or other wet influences, and this must leave the cement porous to a slight extent. It will also, due to the washing out, show a salty bloom on the work on dry days.

To Clean Discoloured Washing Soda.—Washing soda goes a bad colour with age, and is usually put to dish-tub washing and not for clothes washing. Such soda may be cleaned to a fair extent by washing it in a little cold water, then draining off the dirty liquid and drying the soda in a warm oven. The correct way of cleaning the soda, if possible, is to calcine it, then dissolve in water and evaporate until it crystallises out again.

Common Terms for some Preparations of Sodium.—Common or table salt, chloride of sodium; Glauber's salt, sulphate of sodium; marine salt, chloride of sodium; salt of soda, carbonate of sodium; washing soda, carbonate of sodium (hydrate); wonderful salt, sulphide of sodium; baking powder, bicarbonate of soda, with tartaric acid.

Removing Soda Stains.—(*a*) If soda should stain an oak floor, it must be bleached out as follows. Mix a little chloride of lime with water to a paste, spread it thinly on the stained part and let it remain half an hour. Remove with a sponge, and apply to the part a solution of 1 part of hydrochloric acid and 9 parts water and leave for another half hour. The marks should now be gone, but it may be found that some of the colour of the wood has been bleached out also, and this must be toned down with a little colouring matter. Vandyke brown dissolved in ammonia is suitable, but every care must be used in applying it sparingly as too light a tint is easily darkened, but too dark a colour is not easy of remedy.

(*b*) Soda-water will quickly mark a polished wood surface. The liquid should be wiped off directly it gets on, if possible, failing which a rubbing with linseed oil may restore the part. If this fails repolishing must be resorted to, first cleaning the place with finest glass-paper.

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SOLDERS, SOLDERING AND BRAZING.

(*See also* ALLOYS, LEAD BURNING, TINNING, ETC.)

SOLDERING is broadly divided into two kinds of work, soft soldering and hard soldering. With the former, the solder is composed of lead and tin, while, with the latter, the solder (spelter) is composed of copper and zinc, with occasionally silver. In making up soft solders it is important that no zinc enter in the composition. Hard soldering is better known as brazing, and, as a matter of course, hard solder can only be used with metals that will withstand the heat necessary to melt the solder.

Soft Solders (for tinman's use, plumbers' wiped joints, and the mouth blow-pipe.

Tin.	Lead.	Melting Temperature in Degrees Fahr.	Uses.
1	3	480	Coarse plumbers' solder
1	2	440	Good plumbers' solder
3½	6	..	Fine plumbers' solder for seams, angles, etc.
1	1	370	Ordinary copper bit
1½	1	334	Fine tinman's
1½	1	334	Ordinary blow-pipe
2	1	340	Fine and harder blow-pipe solders
3	1	356	
4	1	360	

Hard Solders, or Spelter
(for Brazing).

Copper.	Zinc.	Silver.	Uses.
2	1	..	Hardest, for iron
1½	1	..	Hard, for iron and copper
1	1	..	Ordinary, for brass & copper (melts at lowest temperature).
1	..	4	Hardest
1	..	3	General use
1	..	2	
1	..	1	Softest, but will not burn

Solder for Aluminium. — A patent of recent date, filed in the U.S.A. patent office, reads as follows :—

(*a*) I melt together, for heavy work, 5 parts of tin, 4 parts of lead, and then add to this 6 parts of melted aluminium. I then add 1 part of zinc, and after mixing the same thoroughly, pour the composition into moulds and allow the same to harden. For small or lighter work, I vary the proportions in the following manner : 6 parts of tin, 5 parts of lead, 4 parts of aluminium, and 1 part of zinc.

The above compositions form an alloy which melts at a considerably lower temperature than the aluminium or parts to be soldered, and I find that no flux or scraping of the aluminium to remove the oxide is required, and that the oxide that forms on the aluminium will not affect the joining of the metals or parts when the proper heat is obtained. It is understood, of course, that the last-named composition melts at a lower temperature, and is preferable for light and delicate work.

In employing this solder it is understood that the usual brazing fire of gas and air for imparting a high heat is used, and into which the aluminium or part to be soldered is placed, it being advisable to avoid having too much back heat from the bricks. The parts to be soldered are heated until the outer surfaces brighten or slightly soften. It is best to keep the solder near the flame, so that when a joint is heated sufficiently the solder is ready to melt and drop thereon in sufficient quantities to solder the same, after which a small paddle is used to smooth over the joint. It is, of course, understood that if the aluminium should get too hot it should be allowed to cool for about one minute. When the joint is finished it should be allowed to cool slowly—that is to say, it should not be placed in water, for a quick cooling is apt to crack the soldered joints. I have found that after a joint is cooled and finished it has the appearance of pure aluminium, and will not oxidise or tarnish. ('American Machinist.')

(*b*) Melt together 5 parts tin, 4 parts lead, and add 6 parts melted aluminium. Then add 1 part zinc. Mix thoroughly, mould and cool. For light work, 6 parts tin, 5 parts lead, 4 parts aluminium, 1 part zinc. No flux needed. The second melts at lower temperature. Employ with the usual brazing flame.

(*c*) To make the solder, use the following : Bismuth 10 parts, zinc 30 parts, and pure tin 60 parts. Melt the bismuth and zinc first, then add the tin ; pour the whole into moulds about 1 ft. long and about the size of a pencil. To do the soldering I use a stick of solder, an old nickel aluminium spoke, and a blow torch. Hold the pieces to be soldered in a vice or any convenient place, apply the flame from the torch to them until they are hot enough to melt the solder when it is applied, then scrape the surface to be soldered with a file or scraper. Melt the solder on to each piece and work it around with the spoke ; now hold the parts together in front of the flame, move the torch away and let them cool, and the mend will be as strong as if it never was broken. ('English Mechanic.')

(*d*) In France five different admixtures of aluminium, copper and zinc are used in making solder for aluminium. They are as follows :—

Aluminium, parts by weight	12	9	7	6	4
Copper, ditto . . .	8	6	5	4	2
Zinc, ditto	80	85	88	90	94

The aluminium and copper are first melted together, then the zinc is added. The copper is first melted, and the aluminium, divided into three or four portions, is gradually introduced into the melted copper, a perfect mixture being effected by stirring. When the last portion of aluminium has been added throw in the zinc, and at the same time some fat or resin, then stir quickly and briskly, immediately remove the crucible from the fire and pour the alloy into iron moulds previously rubbed with coal tar oil or benzene.

For soldering aluminium *with the blow-pipe* the following composition is recommended : Silver, 10 parts ; copper, 10; aluminium, 20 ; tin, 60 ; zinc, 30.

For soldering with the common *soldering* iron use : Tin, 95 parts, and bismuth, 5 ; or tin, 97 parts, and bismuth, 3. The flux to be used in all cases is either paraffin, stearin or vaseline. The articles must be well cleaned before soldering, and heated just enough to make the solder adhere.

(*e*) *Soldering of Aluminium Bronze.* To solder aluminium bronze with ordinary soft (pewter) solder : Cleanse well the parts to be joined from dirt and grease. Then place the parts to be soldered in a strong solution of sulphate of copper, and place in the bath a rod of soft iron touching the parts to be joined. After a while a copper-like surface will be seen on the metal. Remove from bath, rinse quite clean and brighten the surfaces. These surfaces can then be tinned by using a fluid consisting of zinc dissolved in hydrochloric acid in the ordinary way with common soft solder.

(*f*) *Hulot's Solder for Aluminium Bronze.*—Lead-tin solder (equal parts of lead and tin) with 12·5, 25, or 50 per cent. of zinc amalgam.

Solderine.—Melted with a match and requiring no flux. This is a special solder sometimes used by electricians for small wire joints, and it has also been sold as a solder for home use, though its qualities for this latter purpose are not very good. Have made some small tube of very soft solder and fill this with powdered resin. This is all that is necessary, and it may be used with a match flame or any heated object.

Cold Soldering.—Various nostrums have been proposed from time to time which profess to be reliable methods of soldering without heat; but, when tried, they have generally proved to be useless. The following recipe, which is due to Fletcher of Warrington, will be found to be more trustworthy. It must be borne in mind that, though the first preparation is tedious, a large quantity of the materials can be made at once, and the actual soldering process is as simple and quick as it well can be.

Flux.—1 part metallic sodium to 50 or 60 of mercury. These combine on being shaken in a bottle. If this is too much trouble the sodium amalgam can be bought, ready made from any chemist or dealer in reagents. This sodium amalgam must be kept in a stoppered bottle closed from the air. It has the property of amalgamating (equivalent to tinning by heat) any metallic surface, cast iron included.

Solder.—Make a weak solution of copper sulphate, about 1 oz. to 1 qt. of water. Precipitate the copper by rods of zinc. Wash the precipitate two or three times with hot water, drain the water off, and add, for every 3 oz. of precipitate, 6 oz. or 7 oz. mercury; add also a little sulphuric acid to assist the combination of the two metals. When combined, they form a paste which sets intensely hard in a few hours, and this paste should be made, whilst soft, into small pellets.

When wanted for use, heat one or more of the pellets until the mercury oozes out from the surface in small beads; shake or wipe them off, and rub the pellet into a soft paste with a small mortar and pestle, or by any other convenient means, until it is as smooth and soft as painters' white-lead. This, when put on a surface previously amalgamated by the sodium and mercury, adheres firmly, and sets perfectly hard in about 3 hours. The joint can be parted, if necessary, either by a hammer and cold chisel, or by a heat about sufficient to melt plumbers' solder.

Dry Soldering.—The process consists in bringing the soldering plane of the heated soldering-iron in contact with the dry lead chloride. When the lead chloride is melted the solder is taken up in the usual manner and applied to the joints to be united. In this manner lead, zinc, copper, brass or iron can be readily soldered with lead with or without the use of soldering liquid. This interposing rôle of lead chloride for soldering purposes is also valuable for metallic coatings in a dry way by melting one metal upon the other. The articles to be coated are brought successively or simultaneously in contact with the melted lead chloride and the metal which is to furnish the coating. According to the shape of the article to be coated, the melting may be effected either upon the article itself or the coating, accomplished by dipping the object into the melted substances. Copper, brass and iron can in this manner be coated with zinc, tin and lead.

Expanding Solder.—A solder which expands on cooling is made of lead 6 parts, bismuth 1 part, and antimony 9 parts (all by weight). This is useful for fixing metals in stone or for filling cracks or holes.

Soldering Fluids and Fluxes. A flux fulfils two purposes, (*a*) the prevention of scale or oxide formation that occurs when metals are heated; (*b*) it aids the flow of the solder and assists in causing adhesion.

(1) "*Killed Spirits*" (known also as chloride of zinc solution).—To prepare this, take some hydrochloric acid (also called muriatic acid) and put zinc cuttings into it. An effervescence will at once take place and zinc should be added until this ceases. When the addition of zinc makes no disturbance the acid is said to be killed, and this is the "killed spirits," so largely used in certain kinds of soldering work. It is used for general purposes, including copper and brass, but not when there is the least difficulty in cleaning the joint afterwards, as active rusting is caused by the spirit if not carefully wiped off. This flux has a cleansing effect, and when used for soldering zinc it need not be "killed."

(2) *Resin*, plain or with oil, is a flux for general use, and no injury by rust or other cause need be feared. It is largely used for lead and tin pipes. It is imperative that the surfaces be very clean, as this flux has no cleansing effect.

(3) *Tallow*, or "touch," is commonly used for lead soldering and has no objectionable features.

(4) *Gallipoli oil* is used for pewter.

(5) *Borax* is used for hard soldering or brazing.

(6) The addition of a small quantity of sal-ammoniac to killed spirits (1 oz. to 1 lb. of spirits) increases the cleansing effect and overcomes the trouble with greasy seams.

(7) *Soldering fluid as used for soft solder in the U.S.A. Arsenals.*—Take killed spirits 1 part, ordinary commercial glycerine 1 part, alchohol (wood or grain) 1 part, and mix together.

(8) To killed spirit add one-third its volume of spirits of sal-ammoniac, and about an equal quantity of soft water. This has no rusting effect on iron, and is an excellent fluid.

(9) *Gauduin's Fluid.*—For copper and bronze. A mixture of finely pulverised cryolite and a solution of phosphoric acid in spirits of wine.

(10) *Müller's Fluid.*—For copper, brass, and copper alloys. This consists of a solution of phosphoric acid in alcohol. Dissolve phosphorus in nitric acid and evaporate the solution to drive off any excess of nitric acid. Mix the syrupy mass with an equal quantity of alcohol. In use the phosphoric acid dissolves the oxide, and the combination, which melts under the soldering iron, is displaced by the melted solder which then comes in contact with the bright metal surface exposed.

(11) *A New Fluid.*—Dissolve 1 part of lactic acid and 1 part of glycerin in 8 parts of water. This is not corrosive nor injurious to those constantly using it. It is said to be harmless if used for fruit tins.

(12) *Soldering Paste.*—Mix starch into a chloride of tin solution until a thin paste is obtained. It is often more convenient of application than a fluid.

(13) *Flux for Brazing.*—The following is an extract from a patent filed in the United States.

"Among fluxes in use for hard soldering and brazing, borax has hitherto been best because, unlike other fluxes, it is equally applicable to all cases of brazing, and because it surpasses all other materials in dissolving different oxides. The use of this salt would be universal were it not for the fact that during the expulsion of its water of crystallisation by heat it intumesces so strongly that it is shifted from the place where it has been put, and often falls, together with the spelter mixed with it, into the fire. For this reason the operator must start with an excess of the flux, and must add more thereof during the brazing operation. Much material and labour would be saved therefore, if this objectionable property of borax were set aside. A further drawback to the use of this salt is that the surfaces to be brazed must be carefully cleaned before the borax is applied, and even contact with greasy or dirty fingers frequently spoils the surface for brazing. By this invention the foregoing objections are overcome by substituting for borax constituents which form sodium borate during the brazing operation. Such constituents are boric acid and a sodium salt, like sodium carbonate. The action of the mixture containing sodium carbonate is as follows:—When the surface to which the mixture has been applied is heated, or even if the mixture is applied wet, the sodium carbonate cleans the surface from grease and the like, and then frits itself on to the part thus cleansed. The boric acid tends to intumesce somewhat; but being intimately mixed with the sodium carbonate it is held in place thereby. When the mixture is further heated, the carbon dioxide is evolved and sodium borate is formed. The latter is anhydrous under these conditions and does not intumesce. The dissolution of the oxides from the metals to be brazed is very energetic and rapid. In what has been said it is implied that the proportion in which the constituents are mixed is such that sodium borate is formed on heating the mixture; but either constituent may be used in excess of this proportion without affecting the invention. An addition of sodium chloride to the mixture enhances the effect by rendering the molten mixture more fluid."

The following is the "claim" of this patent:—

"1. A flux for brazing containing sodium carbonate and boric acid intimately mixed together, substantially as shown and described.

"2. A flux for brazing, containing sodium carbonate, boric acid, and sodium chloride intimately mixed together, substantially as shown and described."

Jewellery Solder. — In the manufacture of jewellery the first essential operation is soldering. To solder two pieces of metal together, an alloy is used which melts more easily than either of them. It is a well-known but unexplained fact that alloys melt at a temperature less than the metals of which they are composed. Thus, if some common solder, composed of lead and tin, is heated to a temperature much less than that of copper, it will amalgamate with and melt into the copper. For this purpose, however, the copper must be perfectly clean. To clean it, mere scraping with sand or emery paper is not enough; for the heat would cause oxidation, and thus continually recoat it with oxide. We need, therefore, a solvent for the oxide which shall not be driven off at the soldering heat.

For soldering brass, copper, or tinned iron, a solder is used composed of lead and tin, called plumber's solder, and made hard, i.e., one lead to two of tin; medium, and soft, i.e., one lead to one of tin. The copper or brass is well cleaned, and then covered with a little resin, or else with liquid chloride of zinc, often mixed with sal-ammoniac. When heat is applied, the water in which the chloride of zinc and sal-ammoniac are dissolved is driven off, and the salts then fuse into a liquid state, in which condition they powerfully dissolve the oxides on the metals, and allow the solder to adhere.

But plumber's solder is weak, and would never do for jewellery, because any trace of lead in or upon gold instantly permeates deep into the metal, and renders it brittle. We thus require a harder solder. This is to be found by mixing gold with silver, copper, or brass.

Here, however, we are presented with a fresh difficulty. The brass or silver is volatile, and at a great heat might be driven off. Again, the chloride of zinc and sal-ammoniac, that answered as fluxes at the low temperature of plumber's solder, must be replaced by some solvent which better resists heat.

The danger of volatilisation of the more volatile parts of a solder is guarded against by heating the work well before the solder is put on, and a convenient flux is found in borax.

There is, however, yet another danger. If a small piece of gold is to be soldered to a large piece the small piece gets heated first, for its surface being large in proportion to its bulk, it absorbs heat rapidly. In consequence, the solder rushes off to the small piece and bathes it, leaving the larger piece dry.

Moreover, borax presents difficulties, for it contains a great quantity of water of crystallisation, which causes it to bubble up when heated, and dislodge the work, and burst open joints in which it has been put. These difficulties may, however, be got over.

First, as regards the borax, if it is melted (so as to drive off the water) into a brittle glass, and then finally ground up to an impalpable paste with the petroleum which has been described for use with grisaille, it will give no trouble by bubbling. I believe this plan is new, and it is certainly effective.

In the next place, care should be taken to heat the larger pieces first. Thus, if a very small bit has to be soldered on to a large thin surface, the heating should be done from the back of the bigger piece.

Plumber's Work.

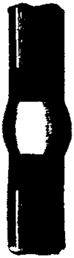

FIG. 116.

To make an upright joint, Fig. 116, get the metal well heated and use just before it becomes blood colour; have a good iron in the fire ready for using. Having prepared your pipe (to enter about a quarter of an inch), next get some shaving or paper, and make a collar to catch the metal as it falls, after being splashed upon the cleaning where the pipes are to be jointed. The collar is usually made with shavings worked into a wisp, and tied round the pipe close up to the joint, leaving about 2 in. space between the bottom of the cleaning and the collar, so that the solder lying upon the collar may impart any heat it may retain to the pipe: it will be found easier to wipe the joints if the solder is kept close to the pipe. On large jobs it may pay to make a lead collar, to catch the metal as it falls; this collar is cut out of sheet lead about 4 to 6 in. wider than the pipe, with two ends to lap over each other. The collar is pear-shaped before fixing, and is generally supported by driving a chisel into the wall.

The metal is usually splashed on the pipe by means of a splash-stick—a small stick cut and shaped like a miniature cricket-bat. Some plumbers carry a splash-stick made from hoop-iron, but the original piece of stick is much preferred, as it does not scratch the soiling, as the heat of the solder chars the wood, and makes it soft. The American plumber pours the metal on the cloth, and allows it to run from the cloth on to the joint. If the metal is good and not too coarse, and the plumber is an adept at his work, the joints may be made without an iron; but the usual method is to use an iron on soil-pipe work. The iron should be well heated to a blood colour and cleaned with an old file, called a rubber, before the plumber has it put into his hands. It is the helper's work to see that everything is in order for the plumber when he is ready to wipe the joint.

For underhand joints, Fig. 117, the pipe is prepared the same way as for upright or vertical joints, and the metal or solder treated as before; the only difference in this work being the quality of the metal, which should be a little coarser than for upright work. It will be seen that it is generally better to leave underhand joints till the last, as the solder always gets

FIG. 117.

coarser as worked. If the solder is too fine the tin will run to the under part and prevent the worker getting away from the bottom of the joint. When the metal is poured on for this joint, it should be gradually poured over the cleaning, always taking care to keep the cold metal off the soiling; this is done by keeping the pipe well heated, by pouring, or rather throwing, the metal in small quantities from the ladle. If the metal is too hot it will be quite a work to keep it from burning through, but, as practice is everything with the plumber, as it is with other trades, I can only say, "If at first you don't succeed, try again."

The proper length of a 4-in. joint should be about 3 in.: under this length they look dumpy, and above this length they are more awkward to solder, and the metal used is simply wasted.

Overcast joints, Fig. 118, are seldom made by modern plumbers nowadays, and never by a good English workman.

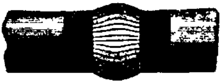

FIG. 118.

There are different methods for making this joint—for instance that adopted by the French plumbers, who generally make the joint with a spirit-lamp, and the solder in sticks. The flame of the lamp is brought to play upon the metal and cleaning, and the solder gradually worked on the pipe. When he has sufficient metal or solder placed upon the pipe, he works it round with a bit of greased cloth of any description, not, as we do here, with a tick or moleskin cloth of nice proportions. After he has formed the joint roughly he has a tool very like a small turnpin on a piece of iron wire; this is used for giving the joint the finishing-touch, or to make it look as if overcast. The body of solder is warmed up after the joint is formed, and the greased turnpin-like tool rubbed up and down the joint, giving it a ribbed or overcast appearance. I have heard a good deal said about French plumbers, but as plumbing is the art of lead-working, we must not throw discredit on the ability of the French members of the craft, as we might learn a great deal more from them than most of us dream of in the art of working lead.

A tafted block or flange joint is shown by woodcut Fig. 119. This makes a first-class connection for pipes not subject to any great change in temperature; hot water should never be let into pipes fixed in this way. The block having been fixed as before described, the joint is formed by tafting the female end of the pipe about to be united over in the form of a ledge to receive the solder, and then cleaning the tafted piece and the male end of the pipe about 1 in. up, after which the joint is wiped. It is called a "block joint" only when supported on a wooden block. Care must be taken to see the arris is not too sharp, but nicely rounded to prevent the wood cutting through the lead: this is generally done by the plumber with his rasp. In first class work the joint should have a lead collar or flange about 3 in. wide, which is sometimes soiled all over although many plumbers like to see a portion of the clean lead on the

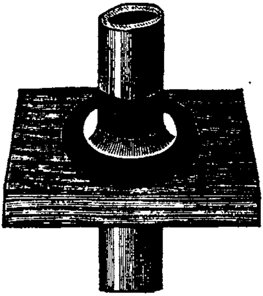

FIG. 119.

outside of the collar. Fig. 120 shows the collar on plan with section through pipe, before preparing the cleaning for the joint. The reason why hot water should never be led into a pipe fixed with block-joints is that the sudden expansion will soon cause the pipe to crack near the joints, owing to the contraction which follows in cooling after the hot water has passed, and which always tends to pull the pipe in two at the block, which is too stiff to allow the pipe to expand and contract freely.

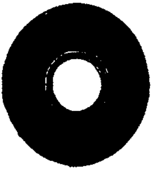

FIG. 120.

Branch joints, Figs. 121 and 122, are those where the horizontal pipes enter the vertical pipe, and *vice versâ*. They require making very carefully, as the least burr or raggedness on the interior of the pipe would cause an obstruction to the paper and matter passing through it. One of the most important things a plumber has to contend with is to leave nothing for hair or paper to lodge upon at the joints. It is surprising to see the vast quantity of hair that will be taken out of a stopped waste pipe, either of lavatories or sinks of any kind if stopped at the joints. The branch joints are prepared in the following way:—Cut a slit in the pipe that is to be branched into, with a small round hole at each end. If for a soil pipe widen out the hole with a bolt or bending pin, and when wide enough use the dummy, taking care to leave the lead standing up ½ inch at least above the pipe at the ends, and the sides level. Soil carefully as for other joints; then mark round the prepared portion with the compasses or shave-hook, guided by the thumb and fingers, say 1 inch deep at the sides of the joint, 1½ inch at the ends, so that the cleaning looks a little oblong, see Fig. 123. Plumbers generally shave their joints as most suited to their wiping, and practice usually determines the width of the cleaning. Any pipe branched into the main pipe should always have an easy fall towards the drain or sewer if used

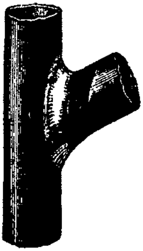

FIG. 121.

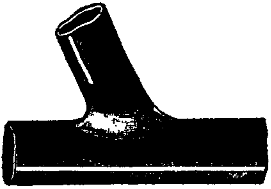

FIG. 122.

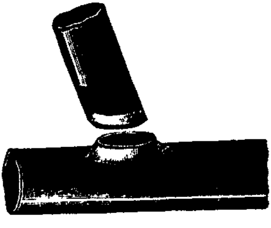

FIG. 123.

for soil or waste pipes; for those under pressure it is not so important: still, it is better to have a rule and adhere to it for all kinds of branches, and the rule is to let the joints enter the way the stream flows.

When wiping branch joints support your pipe close to the joint, and have a board underneath to catch the metal as it falls from the cleansing when splashed on. A small piece of board should be placed under the pipe to support it and prevent it from sagging when making the joint, as it is very apt to do when heated. The branch piece should be securely fixed by struts to take the weight of it, or be otherwise held firmly in its place when being wiped, and not heavily weighted, as it would tend to flatten the pipe, the lead when warm giving way under the least pressure. Horizontal branch joints, or connections to horizontal soil or waste pipes, should have a fall where possible of 1 inch at least to every foot run, and more where convenient.

Where the soil pipe runs horizontally, as Fig. 122, it is necessary and important to pay careful attention to the position of the pipes where branched into each other, and it should be constructed in such a way as to allow a piece of wood equal to twice the diameter of the pipe to pass through the horizontal pipe with the stream and enter the down pipe; a connection is bad, in fact, if 1¼ inch pipe will not easily allow a match to pass through it, the usual length of which is about 2½ in., just double the diameter of a 1¼ in. pipe. If the pipe that is to be branched into a horizontal one is upright, bend slightly or curve the end of the upright pipe where it enters the horizontal soil pipe, to give it the rake or fall required to allow a free passage for the soil, etc., without obstructing the passage in the pipe.

Where short lengths of soil pipe are fixed instead of wiped joints, taft, or round or bead joints, Fig. 124, are sometimes made, and may be used with safety if properly worked. These joints are very neat in appearance, and if well made are as strong and durable as any kind of joint that can be used; the only drawback is that they must be made on the bench, or where the pipe can be turned over, so that the metal may be floated on to the lead as the pipe is being turned.

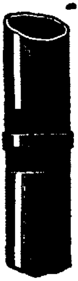

FIG. 124.

To prepare this joint, see that both ends of the pipe about to be jointed are perfectly true and even, and then rasp the two edges on the bevel, so as to form a small groove, prepare with soil, etc., as in making soil-pipe joint to take the metal. The joint is made up with the metal by means of the hatchet bit, and then floated in small lengths with it. The bit is placed across the seam when floating or finishing off (not as in floating soil-pipe, the same way as the seam); as soon as the metal flows, lift up the bit and drop it on further round the joint, taking care that you do not allow the previous portion of the metal operated upon to set, otherwise the joint will present a ragged appearance when finished, showing clearly that the workman did not understand the nature of the metal he used or the method of using it.

It often happens, more especially when new work is being made good to old, that joints in very awkward and inconvenient places have to be made, for instance between two 9 in. joists, with a ceiling under the pipe, which must not be disturbed. This is a time when the plumber requires to put on his considering cap; yet, with a little thought, the joints may be easily made, without either burning the hands or wrist, or in any way interfering with the quality of the work. To make a joint of this description, cut the pipe away at the top side, nearly one-third through it, and say 4 in. long from the position where the two pipes join each other, see Fig. 125, on the under side form a groove, so as to receive a body of solder, and shave the pipe clean and solder it internally to the height cut away, taking care, of course, to leave the pipe unobstructed where soldered. Next make a capping-piece of sheet lead, and place it over the portion of the pipe cut away, and scribe the same on the pipe, soil the outside as for soldering, and shave the pipe and capping-piece, and wipe round in the usual manner. Fig. 126 shows the section through inside joint and cap fixed in position ready for wiping. The result will be a joint part inside and part outside, the latter portion being on the top of the pipe; this, it will be seen at a glance, makes a first-class joint. This system may also be employed for making upright joints in cases where the wall must not be cut through, or where you cannot get to the back of the joint to splash on the metal or wipe it, or the pipe being fixed in faced stonework which must not be cut away.

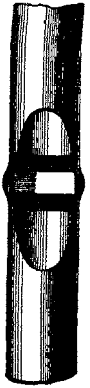

FIG. 125.

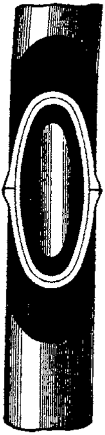

FIG. 126.

The sizes of plumbers' wiped joints that are usually worked to are given in the following table. In regard to the thickness, if the parts are properly prepared and fitted the diameter of the joint—the solder—at the centre should be about half as great again as the diameter of the pipe.

Plumber's Wiping Cloths.—(*a*) A pair of navvy's old fustian or moleskin trousers make the best cloths, but failing these, new moleskin, bought of any working-man's tailor, can be used. The new material should be thoroughly washed to take out the dressing and make it soft. It should then be cut out and folded to the sizes given in the table below, and a little touch, or tallow, rubbed on the working side.

With new material the nap is rather long, and the solder clings to it; but by slightly scorching it with a hot iron or gas flame this does not take place quite so much. The fustian should be cut into strips, the width being equal to the length of the wiping-cloth, and folded with the undergrain of the material in the direction of the wipe when using it. The edges should be free, and the top corners only tacked with sewing thread.

Diameter of Pipe in Inches.	Length of Joint in Inches.	Size of Cloth in Inches.		Number of Folds in Thickness.
		Underhand.	Upright.	
½	2½	3¾ × 3½	3½ × 2½	5
¾	2¾	4 × 3½	4 × 3	6
1	3	4 × 3½	4 × 3	7
1¼	3	4½ × 4	4½ × 3¼	7
1½	3¼	4½ × 4	4½ × 3¼	8
2	3½	4¾ × 4½	4¾ × 3¼	8
3	3½	5 × 4½	5 × 3½	9
4	3⅝	6 × 5	5 × 3½	10
5	3¾	7 × 6	5½ × 3½	10
6	4	8 × 7	5½ × 3½	11

(*b*) If ticking is used, then there are three kinds of bed-tick, namely, cotton, union, and linen. The union tick is the best for making wiping-cloths. The cotton soon wears out because it so easily scorches, and the linen eventually becomes so smooth that it does not "drag" the solder, but slips over it. But the best material is moleskin, or fustian, which can be obtained from any working-man's tailor. Old moleskin, however, is the best. The better parts of navvies' or engineers' old worn-out moleskin or fustian trousers and jackets make very good cloths.

The sizes for wiping-cloths vary according to the ideas of the plumbers who use them. Underhand cloths range from 3½ in. × 3½ in. for ½ in. joints, to 9 in. × 6 in. for 4 in. joints. Upright cloths vary from 2½ in. × 3 in. to 4 in. × 6 in. for joints on pipes from ½ in. to 4 in. in diameter. Branch are from 2 in. × 2 in. to 4 in. × 3 in., according to the size of the pipe. Wiping cloths for seams are similar to those for upright work, and for angle wiping they are from 2 in. × 1¼ in. to 4 in. × 3 in., according to the width of the shaving on the lead; the first dimension in each case being the length of the cloth running from the wrist to the tips of the fingers when held in position for wiping. The cloths vary in thickness from 4 and 5 to 8, 10, and 12 folds, according to the thickness and softness of the material used, and the sizes of the joints for making which they are to be employed.

The fine ribs under the nap of the material should run lengthwise of the cloth. The wrist ends of the cloth should be sewn with needle and thread, and the material should be folded at the fingers' end, the sides being left loose and open. It is always advisable to use a plumbers' iron when wiping joints. ('Plumber and Decorator.')

Electrically-heated Soldering Iron.—Arthur B. Weeks, writing in the 'Scientific American,' describes a practical soldering iron, or copper bit, which can be heated by connecting it up to an electrical circuit. Fig. 127 illustrates the details, the description being as follows: The core C can be made of iron or copper. Cut a $\frac{7}{16}$-in. standard thread on one end, leaving a shoulder so as to make a tight fit on washer A. At the opposite end the washer does not fit over the core; but a hole is drilled for a screw ¼ in. No. 20 round head, ⅝ in. long. The dark lines indicate the mica lining. After fitting the mica on the core, put micanite rings over each end. These will assist in holding the mica in place. The best fit of mica can be made by using thin pieces, and pasting them around until the desired thickness is attained. The insulating washers at each end should be of the best micanite, commonly used for commutator segments, since it is free from mica cement, and therefore very homogeneous.

The copper tip can be made from an ordinary soldering copper, cut off, drilled, and tapped. The outside shell can be made of steel tube with an end piece brazed on, and a tube, D, brazed thereto. Several holes should be drilled in this tube for free air circulation. Have an ordinary tool-handle of wood. The washer B serves also as a rest or guide for the outer shell E. The only point at which the shell is secured in any way is at the copper end, where 4 or 5 small machine screws are used around its circumference.

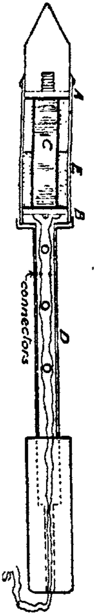

FIG. 127.

Before putting on the shell, and

after the copper is secured in place, all is in readiness for winding on the wire. This is the important part of the operation. German silver wire has been used with more or less success, but it is rather short-lived. Krupp iron wire is extremely desirable, and answers the purpose well. The writer has tried several sizes of wire; for ordinary use No. 26 B. and S. will be found satisfactory. Put the copper in a lathe and pass one end of the bare wire through a mica-lined hole close to the core, as shown on lower side. Much depends on this insulation. Wind carefully, spacing the turns about the thickness of the wire, or a little more. When the first layer is wound, cover it over with mica, the same as was used on the core. Do not let the wire slacken at all. Wind the following layers in the same way, insulating carefully between each. If properly proportioned, there is space for four layers of wire. The copper should heat sufficiently to make solder flow well in about five minutes. Since the mica will not endure excessive heat for long, the wire must be well proportioned. This can easily be ascertained by trial. (When the tool is in use, favour it as much as possible by shutting off current.) When the fourth and last layer of wire is completed, bring the end out through a well-insulated hole at the top of washer, B; and where the winding is finished, pass a piece of bare wire over the last layer of mica, and twist it near the washer where the wire passes through, to keep the wire from slacking up. Tie again at centre and at further end, to retain mica. Make connections for asbestos-wrapped wires in the handle as shown. Make a loop at each end, and pass a small stove bolt through them. Insulate the bolt with asbestos; allow a little slack in handle. Connect a lamp plug to the end of wires, S, allowing as much wire as desired. As constructed, there is no way to make the wires fast to binding posts; this has simplified the construction, and will be entirely satisfactory, provided the tool is not allowed to swing from the outside wire, S. To make this part still more complete, binding posts can be set in, however, in the outer end of the handle, and provided with suitable shell over them. Avoid using fluid flux too freely on the copper while at work, lest it find its way into the windings and cause a burn-out.

This soldering iron should take from 1 to 2 amps. on 110-volt circuit. It can be connected to any lamp socket, and used in perfect safety in places where there is great fire risk. It is especially useful where torches and gasolene stoves and charcoal pots are prohibited. The copper tips are renewable. When the wire is rendered brittle from continued use and a break occurs, it is best to rewind rather than try to patch it up, since it would not last long, but would continue to open right along. The writer has used silicate of soda with considerable success for cementing the wires in place. This can be tried later, and where greater heat is required with special soldering devices, or where wire passing 5 to 8 amps. is used, and mica will not answer at all, some such medium must be used, unless the construction is such that porcelain can be utilised for insulation.

Where silicate of soda is used, the entire iron windings should be baked in an oven before applying current. The material will then be solid throughout.

There are few troubles incident to the use of an electric soldering iron. Usually if an iron fails to give out heat, it is due to an open circuit in the windings or at the connections or in the attachment plug. The attachment plug should be fused. See that it is always intact.

An open circuit may be due also to complete oxidation, as well as to fusing caused by a short circuit in the windings. Again, if the windings become grounded—that is if they touch the shell in places that would short-circuit the coil—the fuse will blow until the fault is remedied. For this reason the insulation must be careful and thorough throughout. Look well also to the insulation where the wires pass through the washer, and cover them thoroughly with asbestos from the point where they leave the washer, using the previously mentioned mica paste.

In damp places it is well to stand on a board while using the iron. In locations containing much iron construction, do not handle any part of such construction with one hand, while using the iron with the other, as a ground on the system may occur, and should another take place on the opposite side while thus engaged, injury is liable to follow.

The Plumber's Blowpipe.—Blowpipes are a means of introducing air, under pressure, to the internal part of an ordinary flame, in such a manner as to supply rapidly the amount of oxygen necessary for perfect combustion. The quicker this oxygen can be mixed with the flame the higher the temperature obtained and the smaller the flame—in fact, given a certain definite amount of combustible matter consumed in a certain time, the smaller the flame obtained, the higher its temperature.

For example, given two gas flames consuming each 5 cub. ft. per hour, the flames being of different sizes, the smallest flame has the highest temperature, and is the most efficient for heating purposes. It will be seen that when a blast of air is directed into the middle of a flame, the size of the flame is instantly reduced, and, provided the air supply is not in excess, the temperature of the flame is increased in exact proportion to the reduction in its size. The simplest and most generally used form of blowpipe is the common plumber's or jeweller's pattern, and it is astonishing what wonders can be done by this simple instrument with a little practice.

With the mouth blowpipe the first thing to be learnt is the art of blowing in a continuous stream, without stopping to breathe—in fact, to render the blowing perfectly independent of the breathing. How to do this is most difficult to describe. It comes as an instinct to most users of the blowpipe, but many fail totally to produce a continuous blast, notwithstanding the practical and theoretical instructions which have so repeatedly been given.

It would appear, as nearly as the process can be described, that the cheeks are filled with air, and that whilst the breath is inhaled through the nose the mouth is closed at the back by lifting the back part of the tongue (not the tip) against the roof of the mouth, the air being taken into the mouth by "gulps" and the cheeks acting as an elastic reservoir. This becomes so easy to many constant users of the blowpipe that it is common to find workmen who can keep up a steady and heavy blast for 15 or 20 minutes without the slightest break or irregularity, the breathing going on steadily and without effort all the time.

Plumbers and gasfitters frequently hold the blowpipe between the teeth without any support for the tip, but very few can hold it steadily so as to get the best work out of it, as the jet of air must be directed into one exact point of the flame to get the best results. The difficulty of holding the blowpipe steadily is greatly reduced by soldering on to the stem, about 1 in. from the opening, a curved plate of tin or Britannia metal, shown in Fig. 127A.

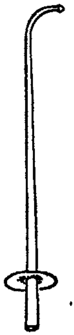

FIG. 127A.

With this addition, the blowpipe is not only held in the teeth, but the plate, being curved to the shape of the mouth, forms a support to the lips, and increases the power of blowing with heavy pressure. The plate is sometimes made small enough to go inside the lips, and is preferred by many when used in this manner. Whether used inside the lips or outside, it is a great advantage, steadying the blowpipe, and reducing the labour of blowing very considerably.

It may be taken, as a rule, that the mouth blowpipe cannot be used with a jet over ⅛ in. in diameter. Few can use one with a jet even this size, and the work which can be done by the mouth is therefore limited in dimensions. It is considered a maximum feat for an average workman to melt an old copper halfpenny on a block of pumice-stone, and any one who can do this may consider himself as good as the crowd, and better than a good many, so far as his blowing capabilities are concerned.

Of the multitude of different forms of blowpipe none is so well suited to general plumbers' and gasfitters' work as the common taper tube, curved to a right angle at the end, with the mouth-plate previously described. It can be used to direct the flame either to the right or left, without the assistance of the hands, and in the most confined and awkward positions. It is a common practice to use with this blowpipe a tallow candle with a broad wick, but the power of this is not sufficient for many purposes. The advantage of the candle is that it is often useful to obtain a light in dark places. The candle may be very well superseded by a small cup about the size shown in Fig. 128, or a shade larger, packed with slag-wool or asbestos, and covered over the top with wire gauze. Rising from the side is a feather, with a tube on top, into which the blowpipe fits tightly. When wanted for use, a few drops of spirits of wine, or a mixture of this and turpentine, must be poured out of a small bottle into the cup, and ignited This then becomes practically a large flame candle, which requires no holding, and therefore sets the hands at liberty, the flame being at the same time larger and more powerful than that of an ordinary candle.

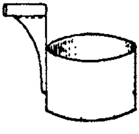

FIG. 128.

For soft soldering lead, tin, pewter, or Britannia metal, the common plumbers' soft solder, containing two of lead and one tin, should be used, but for other and less fusible materials, where there is no danger of melting holes in the work, it is better to use pure tin or Britannia metal as a solder.

Workers in Britannia metal commonly use as a solder thin strips of the same metal as the body of the work. A workman without experience would, at the first attempt, melt both work and solder at once, as both would fuse at the same temperature. This, however, can easily be prevented by directing the point of the blowpipe flame only on the solder (as it may be called), and making a jerking flame by repeatedly closing the blowpipe with the tip of the tongue. This intermittent jerking flame is of the utmost importance in all delicate work, as, by regulating the interval, it is possible to produce and keep an exact temperature, stopping, increasing, and reducing the heat precisely as it is required. By the use of this jerky flame the solder can be kept at exactly the temperature at which it will work in a pasty form, and weld up solid with the body of the work without ever becoming properly fluid.

This process of soldering, as will be seen when hard soldering is treated on, is precisely analogous to the welding of wrought iron; it is in fact a welding process, although commonly called soldering. To assist in shaping and making a neat joint, a blunt metal point (usually steel or iron) is used, whilst the solder is in a pasty state, in the same manner and for the same purpose as a plasterer uses his trowel. Some good workmen affect to despise the plasterers' art as applied to soldering, but usually they find out their mistake, and sooner or later adopt it for many classes of work.

Of fluxes for soft solder there are four in general use. For zinc or iron, hydrochloric (muriatic) acid ; for tin, Britannia metal, pewter, brass, etc., the same acid in which bits of zinc have been dissolved until it will take no more. This forms what is known as chloride of zinc, or "killed spirits of salt." Powdered muriate of ammonia (sal-ammoniac) mixed into paste with water, is equally good, and more convenient to carry about, and many of the highly-praised soldering fluids consist of a mixture of the two last-mentioned compounds. Lastly comes common powdered resin, but this is not well suited for use with the blowpipe, and does not allow the solder to run so well and freely.

It will, of course, be understood that in soldering bulky or heavy work the parts of the work near the solder must be made hot enough, so as not to conduct the heat away, or a good joint cannot be obtained.

It is, therefore, necessary to have some source of heat more powerful than either a candle or the substitute previously mentioned, and in an equally portable form. The best I know is a lamp made of tin, of the form illustrated in Fig. 129, in which either spirits of wine, turpentine, or petroleum oil can be used. The wick holder should be made to take five or six thicknesses of soft wick, 1 in. wide, side by side, so as to form a good body of substance to carry up the fuel freely and make a large flaring flame, as large as can be taken up by a full-sized blowpipe, and the full blowing power available. By raising or lowering the wick, the flame may be made larger or smaller as required for the work in hand, and a tin cap will extinguish it when done with.

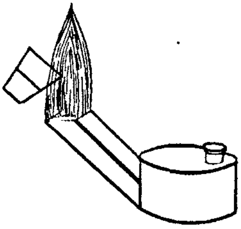

FIG. 129.

When a workman has to carry his lamp about, the cap should fit as closely as possible, and a ring or loop should also be soldered underneath the wick tube not far from the end, into which a loop of chain or cord is fastened. If the lamp is hung by this to the handle of the tool basket, there need be no fear of a mess, as the open end will always be upwards. The filling hole in the box must always be closed with a screw cap or well-fitting cork.

For odd work, in places difficult of access, a more handy arrangement can be made by dipping strips of soft flat wick in tallow and placing them, whilst the tallow is still soft, in a pile, squeezing them together so as to form a solid mass of wick, saturated with tallow, measuring, say, 1 in. by ½ in. in section. These blowpipe candles or torches can be easily and cheaply made in quantities of any size, and should, when cold, be wrapped in two or three folds of paper, which can be torn off close to the burning part as required. The paper serves as a holder, and catches any drip, provided too much tallow has not been used in the manufacture.

Where available, there is no fuel to equal gas for general blowpipe work, and in using the blowpipe already referred to, with gas, it is usual to cut a notch or groove in the upper side of the open end of a ⅜ brass tube, so as to allow the top of the blowpipe to rest in it, pointing in the same direction as the opening in the gas pipe. The blowpipe tip should then be placed in the notch, and a wire bound round both in such a manner that the blowpipe is held firmly in position, and still can be easily drawn out backwards. This arrangement forms a carrier for the blowpipe, which leaves the hands at liberty, and enables the whole attention to be directed to the work in hand. A short length of tube made like this could be carried in the tool-bag, and connected to any available gas supply.

For hard soldering, where the solder used melts at a heat approaching redness, and sometimes at a still higher temperature, the same form of blowpipe and the same source of heat are commonly used, except that as the work is usually done in fixed workshops, the sources of heat do not require to be portable, and are therefore usually confined to gas, or, where this is not available, to the lamp previously referred to, the lamp having fixed on the upper side of the wick tube, in a convenient position, a support of wire, or other material, to carry the front of the blowpipe. Sometimes the blowpipe is made as a simple straight tube, sliding in a loose collar, the blowpipe in this case being about 3 or 4 in. loug. At the opposite end of the jet is fixed about 14 or 16 in. of small indiarubber tubing (feeding-bottle tube), which is used for blowing.

The sliding motion of the blowpipe is necessary, so that the jet can either be drawn back, giving a large rough flare for general heating, or it can be pushed into the flame, so as to take up part only and give a finely pointed jet on any part where the solder requires to be fused.

When gas is used, the sliding motion of the blowpipe is not necessary, as the flame can be altered equally well by the gas tap, and it is therefore usual to make gas blowpipes with fixed jets.

The fluxes used for hard soldering may practically be reduced to one, *i.e.* borax. No other is of sufficient general advantage to be worth mentioning.

For brazing, where powdered or grain spelter (a very fusible brass) is used, the borax is mixed as a powder with a spelter, usually with a little water, but sometimes the work to be brazed is made hot and dipped into the dry powder mixture, which partially fuses and adheres. In either case, care is requisite not to burn or oxidise the grains of the spelter with the blowpipe flame, or it will not run or adhere to the surface to be brazed; and for such small work as can be done with the mouth blowpipe it is better to discard spelter entirely, and use either common silver solder, which is an alloy of one silver and two of tinned brass pins, or what is still better an alloy of thirteen parts copper and eleven parts fine silver. If fine silver is not easily to be got, the same alloy can be made by equal weights of copper and coin silver.

The solder should be rolled into thin sheets, cut into small bits of the shapes and sizes required, and put into a small saucer, containing a rather thin pasty mixture of powdered borax and water. The surfaces of the joint to be soldered should be brushed with this mixture, using a small camel-hair brush, the bit of solder being put in its position either with the brush or a fine pair of tweezers.

The heat of the blowpipe must then be applied very slowly. The borax dries up and swells enormously, frequently lifting the solder along with it. The borax then sinks down again and begins to fuse. There is now no risk of blowing the solder away, and the full blast can be at once applied, directing the flame principally round the solder so as to heat the body of the work. When hot enough, the solder begins to fuse and adhere to the work, and the flame must now be instantly reduced to a small point, and directed on the solder only, which usually fuses suddenly. The instant the solder runs, the blast must be stopped by the tip of the tongue, or in delicate work mischief may be done which may take hours to make good. One great difficulty with beginners is in soldering two or more parts in exact positions relatively to each other, these parts being of such a form that they cannot be held in position.

The way to overcome the difficulty is this: With a stick of beeswax, the end of which has been melted in a small flame, stick the parts together as required. The wax is sufficiently soft when cold to admit of the most exact adjustment of parts, and it must surround the parts only which are to be soldered. Make a mixture of about equal parts of plaster-of-Paris and clean sand, and stir this up in a cup or basin with sufficient water to make a paste, turn it out on to a sheet of paper, and bed the work to be soldered into it, taking care that the part covered with wax shall be freely exposed.

When this is set hard, say in about ten minutes, slowly warm it over a Bunsen flame, or near a fire (if suddenly heated it will break up); wipe the melted wax off with a small ball of wool; apply the borax, and solder as before mentioned, and continue the slow heating up until the whole mass is hot enough to complete the soldering with the blowpipe.

If a light bit has only to be carried or held in position after fixing with wax, as before mentioned, a bridge or arm may be made between the two pieces with a very stiff paste made of common whiting and water, or a mixture of clay, whiting, and water. This being only small in bulk, dries much more quickly than the plaster and sand, but it requires also very slow heating at first, so as to drive the moisture out gradually, otherwise, it explodes as steam is formed inside, and the whole work has to be recommenced.

The Indian jewellers in making filigree work use clay alone for holding the parts together, but it is very slow in drying, and requires much more care in use than either of the forms given.

When soldering, the work has to be supported in such a manner that it can be turned about and its positions altered quickly, more especially when a fixed blowpipe is used, and for this purpose it is common to use either a lump of pumice-stone or a small sheet-iron pan with a handle, and filled with broken lumps of pumice, broken charcoal, and plaster-of-Paris, or other non-conductor. The best material is willow charcoal, and the best result can be obtained by its use, as burning with the heat of the blowpipe, it gives off heat and assists the workman, giving a greater power than when any other support is used. Oak charcoal is not admissible, as it crackles and disturbs the work. For a permanent support, which does not burn away to any practical extent, the best is a mixture of finely powdered willow charcoal and a little china clay, made into a stiff paste with a rice-flour starch, and rammed into a mould. These are to be bought in many shapes, and are the most convenient for all purposes.

The receipts for making gold solders will be found in books treating specially on gold working. As a rule, the alloy, or rubbish which is commonly sold as gold, can hardly be safely soldered with anything much better than common soft solder, and it is not safe for an amateur to attempt to repair any of the so-called gold jewellery, which sometimes contains the large proportion of one of gold to two or three of alloy, and in addition is often weighted inside with pewter, lead, or something of the kind equally unsatisfactory to the purchaser when he discovers it by the total collapse of his cherished ornament.

Speaking generally of the mouth blowpipe, the most practised users, as a maximum feat, might, with gas, soft solder a 3-in. lead pipe, or, with a lamp, do the same with a 1½ in. pipe. In hard soldering (with silver solder or spelter), it is usually as much as can be done to solder properly any work weighing over 3 oz. if gas is used; or about half this weight with a lamp; although in exceptional cases, using a charcoal support, these weights may be exceeded, and more especially if the bulk of the work is heated up by a fire or other means so as to admit of an extra strain being put on the lungs for a short time for finishing only. It is a common practice for heavy or awkwardly-shaped work—where the heat is liable to be conducted away quickly—to support the work on a bed of burning coke or charcoal, using the blowpipe only for running the solder whilst the body of metal is heated by the burning coke. By this assistance the capacity of any blowpipe is doubled, or more than doubled, and when work is to be done beyond the capacity of the blowpipes available, this remedy is a valuable one. (Thomas Fletcher, F.C.S.)

* * *

STAINS AND STAINING.

(*See also* DYES AND DYEING, POLISHING, *etc.*)

THERE is such a close relationship between stains and dyes that it would be desirable to treat both together, were it possible. It is difficult to make a true dividing line, as will be seen when it is stated that leather is stained while kid gloves are dyed. Reference should be made to both.

Bricks.—*See* **Stone.**

Floors.—(1) Get the wood clean, have some Vandyke brown and burnt sienna ground in water, mix it in strong size, put on with a whitewash or a new paint brush as evenly as you can. When dry, give two coats of copal or oak varnish.

(2) If the floor is a new one, have the border well washed. Smooth with glass-paper, rubbing always with the grain of the wood. Varnish with good oak varnish, put colouring matter into the varnish to suit your taste, but umber is best; if the floor is old and blackened, paint it.

(3) If old floors, you will not make much of staining anything but black. The floor is to be well washed (lime and soda are best—no soap), the dye painted on, and, when dry, sized over and varnished with elastic oak varnish.

(4) Take ½ lb. logwood chips, boil them briskly for ½ hour in about 5 qt. rain-water, and strain through muslin. To this liquor add 6 oz. of annatto (in the form of cake—not the roll); add also 1 lb. of yellow wax cut up in very small pieces. Place these over the fire, and let the wax melt gently, stirring it all the while. When melted, take the mixture off the fire; do not let it boil. Then with a paint brush lay it on the floor as hot as possible, brushing it always the way of the grain. Next day polish with a hard flat brush made of hair, which may have a strap nailed to the back of it in which to insert the foot. The floor is afterwards kept bright with beeswax

alone, a little of which is melted and put on the brush. Take care that the floor is thoroughly dry before commencing operations.

(5) Melt some glue-size in a bottle; next get a piece of rag, roll it into a ball so that it will fit the hand nicely, cover this with a bit of old calico to make a smooth face; dip this into the size, and rub in a bit of brown umber; then go ahead with your floors, working the stuff light or dark as required. Keep the motion with the grain of wood; when dry, stiffen with polishers' glaze.

(6) Take Judson's dyes of the colour required, mix according to the instructions given with each bottle, and apply with a piece of rag, previously trying it on a piece of wood to see if colour would suit; rub with sandpaper to get off any roughness that may be raised with the damp, and varnish with fine pale hard varnish, then slightly sandpaper and varnish again. Another method is to boil 1 lb. logwood in an *old* boiler, then apply with a piece of rag where the stain is required; when thoroughly dry, sandpaper as before, and well rub with beeswax to polish. This last process looks best when finished, but it requires a lot of elbow grease for a few months; it is extremely durable. To prevent the stain running where you do not want it, paste some stiff paper.

Glass.—*See* GLASS, also PAINTING GLASS.

Horn.—(1) Black.—After having fine sand-papered the horns, dissolve 50 to 60 gr. nitrate of silver in 1 oz. distilled water. It will be colourless. Dip a small brush in, and paint the horns where they are to be black. When dry, put them where the sun can shine on them, and you will find that they will turn jet black. When done, polish off.

(2) Black.—5·5 lb. burned lime is slaked in a little water, so that a powder-like hydrate of lime is obtained; this is mixed with 2·2 lb. minium, and this mixture is formed into a thick paste with such lye as soap-boilers use, having a specific weight of 1·036. The articles of horn are placed in this solution for 24 hours; they are then taken out, rinsed off with water, dried with a cloth, brushed over with rape-seed oil, and then again rubbed dry.

(3) Black.—0·14 oz. silver is dissolved in 2·1 oz. nitric acid (aquafortis), and this solution is applied several times to the article to be stained, but it is absolutely necessary that the first coat should be entirely dry before another is applied. The articles are then burnished and made bright.

(4) Blue.—Stain with aniline. Or stain green as (6), then steep for a short time in a weak solution of sulphate of indigo, with a little cream of tartar.

(5) Green.—0·52 oz. fine indigo-carmine is dissolved in 2·1 oz. rain-water. Then 0·175 oz. picric acid is dissolved in 2·1 oz. boiling hot rain-water, and both solutions are mixed together. A very beautiful, durable green colour will in this manner be obtained, and can be used for the various manipulations.

(6) Green.—0·35 oz. aniline green is dissolved in 4·2 oz. spirits of wine, and the horn to be stained is treated with this solution. All the different shades of green may be produced by adding blue or yellow stain.

(7) Green.—4·2 oz. copper cut up finely and gradually dissolved in 13 oz. nitric acid (aquafortis), and the articles to be stained are boiled in this solution until they have assumed a fine green colour.

(8) Purple.—17·5 oz. logwood is boiled in 4·4 lb. milk of lime, and the same method is observed as given in (9).

(9) Red.—17·5 oz. red Brazil-wood is boiled for 1 hour in 4·4 lb. milk of lime, and filtered through a cloth. The articles of horn, ivory, or bone to be stained are boiled for 1 hour in a solution of 1·05 oz. alum in 17·5 oz. water. They are then placed in the above stain, and allowed to remain there until the desired colour has been produced. Articles stained in this manner will acquire a beautiful purple colour by dipping them in alum-water.

(10) Bright Red.—8·75 oz. logwood and 8·75 oz. red Brazil-wood are boiled in 4·4 lb. milk of lime. It is applied in the same manner as (9).

(11) Tortoiseshell.—Make a paste of 1 lb. white litharge, 2 lb. powdered quicklime, and 1 lb. of soda ash or potash, with water. The parts of the horn which are to become dark are covered with this paste, and allowed to remain in contact for about 24 hours, until the latter has become entirely dry. The horn is then cleansed with a brush. If the marks are not plain enough repeat two or three times. When this is done colours mixed with whiting and water can be applied to complete the mottlings.

(12) Yellow.—17·5 oz. alum, free from iron, is dissolved in 4·4 lb. rainwater. The articles are allowed to lie in this for 1 or 2 hours. In the meanwhile 7 oz. yellow berries are boiled with 4·2 oz. carbonate of potash in 2·2 lb. water for 1 hour, and then strained. The articles treated with alum are placed in this decoction, and allowed to lie in it for 1 hour. They are then taken out and dried.

Horsehair.—The horsehair is first washed in soap and water and rinsed.

Brown is obtained by letting the hair lie for 12 hours in a decoction of logwood and limewater at 120° F.

Blue, violet shade, is treated as described in brown, then passed through water to which a little chloride of tin solution has been added.

Blue.—The hair is mordanted in a solution of 2 parts alum and 1 tartar, rinsed and dyed in a solution of sulphate of indigo, then washed and dried.

Red.—The hair is first laid down for 1½ hours in a solution of chloride of tin, and then prepared as blue, violet shade; after rinsing, it is dyed with Brazil-wood and alum, allowed to lie in the bath for 24 hours, washed, and dried.

Ivory.—The pieces are always first polished with whiting and water, and when washed quite clean from the whiting are then prepared for the stain by a short immersion of from 3 to 5 minutes in acidulated cold water, in proportion of 1 part of muriatic acid, the ordinary acid of commerce, to 40 or 50 of water, or in an equally weak solution of nitric acid. This cleansing fluid extracts the gelatine from the surface of the ivory, and is essential to the attainment of a perfectly uniform colour. Extreme cleanliness and the absence of any grease or accidental soiling are as necessary, with which view the work in process of staining is at no time touched by the fingers, but is removed from one vessel to another by flat pieces of wood, attached to each other at one end by a flat metal spring after the form of a pair of sugar-tongs, separate pairs being kept for different colours. Subsequently to its treatment with the acid, the ivory is invariably again placed in cold water that has been boiled, before it is transferred to the stain.

The use of tongs is also essential when such chemicals as silver nitrate, nitric acid, etc., are used, as they may cause sores to the hands. Care should also be used not to breathe the fumes.

(1) Place in vinegar for ½ hour, then in Judson's dyes till the required shade is produced.

Black.—(2) Lay for several hours in a strong solution of silver nitrate, remove and expose in a strong light.

(3) Place a handful of logwood and 1 oz. acetate of iron in about 1½ pints water in a saucepan, and let simmer till reduced to ¾ pint; put the ivory into the still boiling liquid, and let remain for 10 minutes; remove and lay before a fire or in an oven till well dried; afterwards polish with chamois leather.

(4) Make a decoction of 2 oz. logwood dust in 1 qt. water, and strain; dissolve 1 oz. iron sulphate in 1 qt. water; then heat the two stains in separate vessels to 100° F. (38° C.), and immerse the ivory in the logwood for 15 minutes; well wash, and put it into the iron sulphate for 5 minutes.

Blue.—(5) Immerse for some time in a dilute solution of indigo sulphate containing potash. Water 1 gal., sulphate of indigo 1 oz., potash ½ oz.

(6) Elderberries and alum.

(7) Sulphate of copper ½ lb., water 1 qt. Boil together, then steep the articles while the liquor is scalding hot.

Brown.—(8) Alkanet root.

Green.—(9) Boil in a solution of verdigris in vinegar till the desired shade is produced.

Red.—(10) Make an infusion of cochineal in liquor ammoniæ, and immerse pieces therein, having previously soaked them for a few minutes in water slightly soured with nitric acid.

(11) Dip in the tin mordant used in dyeing, and then plunge into hot decoction of logwood, ½ lb. per gal. water.

(12) Dip in a solution of nitro-muriate of tin, and then in lac, to produce scarlet; by then plunging into a solution of potash it will become cherry red.

(13) Boil cuttings of scarlet cloth in water, and add pearlash by degrees till the colour is extracted; add a little rock-alum to clear the colour, then strain. Steep the ivory in nitric acid diluted with twice the bulk of water; take out and plunge into the dye till sufficiently deep. The acid bath must not be too strong, and the ivory should be taken out as soon as the surface becomes rough; the dye bath must be warm, but not hot. A variegated appearance may be produced by covering portions with white wax, these retaining their natural whiteness.

Yellow.—(14) Saffron or turmeric. Immerse the article in a solution of ¼ lb. alum per pint, then boil in decoction of water ½ gal., turmeric ¼ lb., pearlash ½ lb., for ½ hour. Finally boil again in the alum bath to fix the colour.

(15) 0·175 oz. picric acid is dissolved in 1·05 oz. hot water. On the other hand, 0·07 oz. concentrated sulphuric acid is diluted with 0·35 oz. hot water, and the freshly-smoothed articles are laid in the fluid, and frequently turned. They are then taken out, dried off, and placed in a solution of picric acid while this is still hot, where they remain until they are uniformly yellow. A lustre is given them by polishing with soap and water and fine whiting. (This is a very good method for colouring billiard balls yellow.)

(16) 0·35 oz. aniline yellow is dissolved in 10·5 oz. spirits of wine. The ivory is brushed over with this solution or is placed in it. If some aniline red is added to this stain, all shades of colour, from orange to bright reddish yellow, can be obtained.

Violet.—(17) Dissolve together 2 oz. water, 4 oz. nitric acid, ½ oz. tin in powder, ½ oz. sal-ammoniac. (This mixture should not touch the hands, nor the fumes be breathed.) Dip the articles in this, then steep them in a solution of logwood, ¼ lb. boiled in 1 qt. of water.

Vegetable Ivory.—L. Müller finds that objects of this material may be stained by boiling them for a long time in a perfectly clear solution of the desired colouring matter. Aniline red, picric acid, or potassium dichromate, iodine green, sumach, aniline dyes, etc., may be used conveniently. The ivory must be thoroughly clean. It may be bleached by immersion for several hours in a solution of permanganate, and then in sulphurous acid.

Leather.—The following stains for leather are selected from the best authors on the subject:—

Blacks.—(1) ½ gal. vinegar, ½ lb., dry lamp-black, 3 lb. sifted iron rust; mix; let stand for a week; lay 3 coats on hot, and rub with linseed-oil.

(2) ½ lb. good galls, well broken, ¼ lb. logwood, 3 oz. iron sulphate; makes about 2 gal.

(3) Wet with iron liquor and rub with a piece of iron; then oil, or give a dressing of composition made by melting 2 oz. black resin and adding 3 oz. beeswax. When thoroughly melted, take from the fire, and add ½ oz. fine lamp-black which has had ½ dr. Prussian blue mixed with it; thin with turps just before it gets too cold. Apply a coat of this with a rag, and polish with a soft brush.

(4) Ball Black.—For harness leather straps, this is made of ¼ oz. isinglass, ¼ oz. indigo, 4 oz. logwood, 2 oz. soft

soap, 4 oz. glue, softened, and 1 pint of vinegar; the whole is mixed, warmed, strained, and allowed to cool, when it is ready for use.

(5) Hatters' Black.—This black is unequalled for finishing. It is made by dissolving 1 lb. extract of logwood, ½ oz. bichromate of potash, and 1 oz. copperas in 1 gal. water.

(6) Patent Leather Black.—Mix together ½ lb. each of ivory black, purified lampblack and pulverised indigo, 3 oz. dissolved gum-arabic, 4 oz. brown sugar, and ¼ oz. glue, dissolved in 1 pint water; heat the whole to boil over a slow fire, then remove and stir until cool, and roll into balls.

(7) Vinegar Black.—This is the most simple and useful colouring liquid for the trimming shop for blacking leather straps. To make the simplest, and without doubt the best, procure shavings from an iron turner, and cover them with pure cider vinegar; heat up and set aside for a week or two, then heat again and set in a cool place for 2 weeks; pour off the vinegar, allow it to stand for a few days, drain off, and cork up in bottles. This will keep a long time, and while producing a deep black on leather, it will not stain the hands.

(8) Vanadian Black.—This process is due to Sörensen, of Sweden, and he thinks that it will make black dyeing on leather easier, cleaner, and more durable than that obtained by present methods. The leathers to be treated by this process ought to be tanned with nut-galls, and consequently contain gallic acid or its derivatives, which give a black colour on treatment with salts of vanadium. The author admits as well known the compounds of gallic acid with which vanadium ought to produce a black dye, as well as the salts of vanadium which are commonly used for this purpose. It is of no importance what particular time is chosen after the tanning for dyeing the leather black. The dyeing is effected by simply applying over the surface a solution of a suitable salt of vanadium, so that the chemical reaction may take place within the texture of the leather. Thus he recommends as very efficacious a solution of the neutral vanadiate of ammonia, 1 lb. in 10 gal. water. The operation should be conducted at a moderate heat, which is favourable to obtaining a fine black. This process is recommended in place of curriers' blacking for leathers of an open texture, as for shoes, harness, etc. It is easy to produce reserves by applying the solution of vanadium only to some particular parts of the leather, leaving the rest untouched. In saddlery a very elegant effect is produced spontaneously owing to the circumstance that the waxed thread of the seams does not take the colour, but retains its own colour, and appears as a light design upon a black ground. The operator in this kind of leather dyeing does not soil his hands. There is produced a true, penetrating, and durable dye in place of a mere superficial coating, which often requires renewal and becomes lighter with time. ('Teint. Prat.')

(9) 1·2 oz. bruised gallnuts and 17·5 oz. green nutshells are boiled in 26·25 oz. rain-water. When the mixture has boiled 1 hour, the liquor is strained through a cloth. The leather to be coloured is first stained with the solution of iron filings, common salt, and vinegar, as given under purple, before the above decoction is applied.

Blue.—2·2 lb. elderberries are boiled with 1·05 oz. alum, free from iron, in 2·2 lb. wine vinegar, and this solution is also filtered. If leather is to be coloured blue, the decoction of elderberries is applied uniformly with a sponge. When the coating is dry, it is brushed over lightly with solution of blue vitriol in vinegar.

Browns, Russets, Reds, Yellows.—The use of russet and brown leather for reins necessitates the employment of stains of various shades in the workshop, in order that the reins or other straps may be of a uniform colour after being worked. In most cases rein leather is stained by the currier, but when worked the freshly-cut edges need to be stained to correspond with the grain. The stains used are generally made of Spanish saffron and annatto, or of saffron alone, made up in various ways, the most common and reliable being the following:—

(1) Boil a given amount of saffron in water until the colour is extracted; cut a quantity of annatto in urine and mix the two together, the proportions of each determining the shade. The more annatto used, the darker is the colour

(2) Another manner of preparing this stain is to boil ½ oz. Spanish saffron and ¼ oz. annatto in water until the dye is extracted, to which must be added some alcohol to set the colour.

(3) To make a stain of saffron alone, boil a quantity in water until the dye is extracted; strain off, and when cold add alcohol in order to set the colour. The shade may be changed by adding oxalic acid in varying quantities, according to the colour required. The proportion cannot be given with any degree of accuracy, as the colour is a matter of taste, and can be regulated by using greater or less proportions of each article.

(4) Another saffron stain is made by boiling saffron in a small quantity of water until the colour is extracted, and reducing with urine.

In using any of these stains apply them with a cloth, and when nearly dry rub with a woollen rag slightly waxed.

(5) A yellow stain is produced by boiling fustic berries in alum water; the shade may be darkened by the addition of a small quantity of powdered Brazil-wood boiled with the berries.

(6) Another yellowish-red stain is made of Brazil-wood and yellow berries in proportion to suit, boiling them in water until the colouring matter is extracted. This can be applied to sides that have not been stained, when intended for flat reins, halters, etc., in the following manner:—

Lay the leather upon a table, and rub the flesh side with a warm stretching iron; turn it over and moisten the grain side with water, and rub with a copper stretching-iron until the leather is nearly dry; then apply the colouring matter to the grain, and rub with a copper slicker. When the leather is perfectly dry, rub the grain with a glass slicker. An edge stain is made by adding a small quantity of alum to the above-mentioned ingredients.

(7) A brown stain is made by boiling equal parts of pine and alder barks in six times their bulk of water until all the colouring matter is extracted, and when cold adding a small quantity of alcohol. Saffron boiled for 12 or 15 hours gives a good brown stain, to which alcohol must be added to make it set.

(8) Picric acid and water, in proportions of 1 to 10, heated to a blood heat make a good yellow stain. Weld boiled in water also makes a yellow stain. An orange-yellow is produced by boiling fustic berries in alum water. This stain may be converted into a rich brown by washing the leather to which it has been applied, before the stain is fairly dry, with an alkali.

(9) A red stain is produced by boiling Brazil-wood in lye. If mixed with weld it produces a brownish-yellow, well adapted for use on halters and bridles.

(10) An edge stain for russet leather is made by cutting 11 oz. annatto in 2 qt. urine, allowing it to stand for 24 hours, then adding 3 qt. water, and boiling until reduced to one-half the original quantity.

All stains appear to better advantage, and are rendered more durable, by being covered with a shellac varnish, which should be applied after the reins are all dry, and then finished up. The shellac should be applied with a sponge.

(11) A bright orange stain is made by mixing yellow aniline with alum water.

(12) 1 oz. oxalic acid, 1 oz. spirits of salts, 1 scr. bruised cochineal, and 1 pint boiling water, make a good brown stain.

(13) Another red stain is made by dissolving 1 oz. cochineal in ½ pint hot water, and adding 1 gill spirits of hartshorn.

(14) A bright crimson stain is alum or tin salts and a decoction of cochineal.

(15) For sole leather, 185 dr. Paris yellow, 37 dr. chrome yellow, 312 dr. pipeclay, 250 dr. alum, 250 dr. querditron, 185 dr. sulphuric acid, 1¾ pints tragacanth solution, boiled together with 7 pints water, and the mixture, when cold, suitably applied.

(16) Brown.—17·5 oz. dried and powdered nut-shells are boiled for 1 hour in 52·6 oz. milk of lime, and strained through a cloth. This decoction is applied frequently to the leather. 4·2 oz. ground logwood, 4·2 oz. annatto are boiled in 17·5 oz. rain-water, and a solution of 0·52 oz. carbonate of potash in 2·62 oz. vinegar is added to the above decoction.

(17) A brown stain is also obtained by rubbing together upon a marble slab 4·2 oz. umber, 0·52 oz. finest lampblack, in oil, with 17·5 oz. ox-gall.

(18) Yellow.—0·52 oz. saffron, cut in small pieces, is digested in 2·1 oz. alcohol 80 per cent. strong, for several days at a moderate heat. The solution is filtered, and applied directly to the leather.

(19) Yellow.—17·5 oz. ground yellow wood or 17·5 oz. birch leaves are boiled for 1 hour in 2·2 lb. vinegar, and the fluid is strained. The articles to be stained are first covered with a solution of 1·05 oz. carbonate of potash, with a sponge to the leather, which has first been stretched, and when this has become dry, apply the colouring liquor also with a sponge.

(20) Bright Yellow.—1·05 oz. finely-powdered turmeric and 0·52 oz. gamboge are digested at a gentle heat for a few days in 26·25 oz. alcohol 80 per cent. strong, and the fluid is then filtered. The process is the same as (19), either with or without alum or carbonate of potash.

(21) 17·5 oz. barberries are boiled in 2·2 lb. water, and the decoction is filtered. In this case also a solution of alum or carbonate of potash in water is used before applying the decoction to the article.

(22) Yellow.—17·5 oz. wold is boiled in 3·3 lb. water for 1 hour, and used in the same manner as (21).

(23) Green.—1·57 oz. verdigris and 0·52 oz. sal-ammoniac are dissolved in 8·75 oz. wine vinegar. If a small quantity of saffron extract is added to this, a yellowish-green colour, the so-called parrot-green, is obtained.

(24) Green.—If leather is first coated with a solution of Berlin blue, and then with a yellow stain, a beautiful durable green will be obtained.

(25) Violet.—17·5 oz. Brazil-wood is boiled for 1 hour in water, and the decoction is then filtered. Another solution of 4·2 oz. copperas in 8·75 oz. water is prepared, and this is mixed with the decoction of Brazil-wood. Violet stains are also obtained by mixing red and blue stains together.

(26) Red.—8·75 oz. shavings of red Brazil-wood are placed in a bottle, 2·2 lb. wine vinegar is poured over them, and they are digested for 8 days, and stirred frequently in the meanwhile. The solution is then filtered through a cloth. Meantime a solution of 1·05 oz. alum free from iron, in 8·75 oz. water, is prepared, and the above preparation of Brazil-wood is added to this under constant stirring. A very beautiful red is obtained in this manner. The shavings of Brazil-wood may also be boiled in rain-water, and this be compounded with a solution of bitartrate of potash.

(27) Cochineal.—1·05 oz. of the finest cochineal is powdered and digested in 17·5 oz. alcohol 80 per cent. strong, until it is dissolved; the solution is then filtered. More or less cochineal is taken according as the colour is required to be darker or lighter.

(28) Scarlet.—1·05 oz. scarlet berries are bruised, and dissolved in 4·2 oz. alcohol, 80 per cent. strong, and the solution is filtered.

(29) Purple.—8·75 oz. Brazil-wood shavings, or 2·1 oz. scarlet berries, are boiled in 2·2 lb. water in an earthen pot or in a bright copper boiler. The decoction is filtered and compounded with a sufficient quantity of fluid

chloride of zinc to obtain either a light or a dark colour.

(30) Crimson.—A solution of 0·14 oz. cochineal, 0·14 oz. cream of tartar, 0·42 oz. solution of zinc, is prepared. The mixture is thoroughly shaken, and the contents of the bottle are exposed to heat for 24 hours. Spirit of sal-ammoniac is then added in drops until the desired colour is obtained.

(31) A rich permanent brown can be imparted to rein-leather by treating the hides, after they are tanned, to a bath in a liquor made from equal parts of pine and alder bark. The hides are spread in a vat, with liquor enough to cover them, where they are allowed to remain one week; they are then removed, and fresh liquor is applied. By repeating this treatment 3 or 4 times a very rich brown can be produced. Orange-brown is produced by scraping the flesh side after the hides have been removed from the vats for the last time, and sprinkling them on the scraped side with pulverised alum. As soon as each one is sprinkled with the alum, it is laid in another vat, one upon the other, and allowed to remain 24 hours; they are then moistened with the alum liquor in the bottom of the vat, and laid upon the beam and well worked, after which they are rubbed with salt and alum, and rolled up and allowed to remain undisturbed for 24 hours. This salting is repeated 3 times, after which the hides are stretched lengthwise and dried; they are then boarded and worked soft, and treated to a coat of hog's lard and train-oil on the flesh side; in about 2 days they are again boarded, and worked off with a glass slicker. This leather has a fine grain, and retains its softness for a long time.

Calf-kid.—Dyeing black is accomplished either by brushing on a table, or by "ridging" or folding, grain-side outwards, and drawing quickly through baths of the mordant and colour. To prepare them for the colour, stale urine is generally employed. A deeper colour, and one less likely to strike through the skin, is obtained by adding ¼ lb. potash bichromate to 4 gal. urine; or the following mixture may be substituted with advantage, viz.: ½ lb. Marseilles soap dissolved in boiling water, 5 or 6 egg-yolks added, and the whole made up to 4 gal. with water and ¼ lb. potash bichromate. The colour used is infusion of logwood or its extract, or ⅔ logwood, which is best extracted by stale urine or old soak liquor, with addition of a small quantity of soda (1 lb. to 45 lb. dyewood). It is fixed and darkened by a wash of iron-liquor (1 of iron protosulphate in 75 cold water). After being again dried, the skins are grounded with the moon-knife, and rubbed over on the grain with a composition containing oil, wax, etc., and are finally ironed with a flat-iron to give them a fine and smooth surface. Eitner gives a recipe for the gloss: 1 lb. gum-arabic, ½ lb. yellow wax, ½ lb. beef tallow, ¾ lb. Marseilles soap, 2 lb. strong logwood infusion, and 1 gal. water. The water is brought to a boil in an earthen pot, and then the soap, wax, gum, and tallow are added successively, each being stirred till dissolved before adding the next, and lastly the logwood. After boiling for an hour, it is allowed to completely cool, being incessantly stirred during the whole process. ('Spons' Encyclopædia.')

Aniline Dyes.—These dyes are now very largely used for leather, affording, as they do, a wide range of tints and brilliant colours. Some skill and practice is required, however, as some of these dyes work best in an alkaline form, while others are best acid. The currier has to make himself acquainted with this, though great help can be had by consulting the manufacturing chemist who makes the dyes. A further difficulty lies in the fact that different leathers show different results with the same dye, while, yet again, a difference in the tanning process will affect the work. It will be noticed that the aniline colours are practically always spoken of as dyes, whereas the use of stains (made from dye-woods) is termed staining. It is difficult to make a dividing line between the two, for while some consider that applying the colouring fluid with a brush constitutes staining, and dipping constitutes dyeing, yet here there is no regular practice, for paper is both brushed over or dipped according to whether one or both sides of the sheet are to be coloured.

It may be laid down as a rule that, certainly with leather, aniline colours are best applied by dipping. The application of these colours by the brush does not always result in a uniform tint being obtained. Aniline colours affect leather so rapidly that immediately the brush touches the work the colour is fixed, and to go over that part again means a darker tint at that point. If a brush must be used let it be of large size and heavily charged with the fluid colour so as to flood the surface quickly.

In dealing with skin that has been tanned as morocco leather, the tanning is usually the sumach process which makes the leather very suitable for aniline colouring. A good plan before laying the skin over the table is, first to clean the table, then brush it over with a fluid made by boiling crushed linseed in water, using the strained liquor. This is slightly adhesive and will cause the skin to cling to the table. It also prevents the staining fluid from discolouring the table, and it can always be easily cleaned off by washing with hot water.

When the skin is laid on the table, flesh side down, sponge it over evenly with clean tepid water. Then either roll or press it with a tool to distribute the moisture and remove superfluous water. The mordant is then applied, the purpose of this being to allow the colouring liquor to flow and fix evenly. In many cases the mordant acts chemically, while in other cases morocco leather does not need a mordant at all. Several skins can have the mordant applied and be laid aside for a time for the application to penetrate. The first skin is then taken and with a large hair brush the dye liquor is applied. Give all the skins one coat, then go over them again with second and successive coats. Three to four coats are usual.

Following this there may come the application of a modifying liquor, often called a topping-agent or striker. This is to give a special tone to the previous colour, or it may be a mordanting liquor. The last process is to wash off all superfluous colouring matter, with abundance of water and a brush, or preferably with running water. The skin is then hung in the drying loft, where there is plenty of air, but on no account must the sun shine on it while drying. This completes the colouring of the leather, and the finishing process follows. This will be found under the heading of Leather.

The mordant most commonly used for aniline colours is (for an acid) tannic acid—about ½ lb. to 1 gal. of water—while, for an alkaline, sulphate or phosphate of soda, 1 part to 100 of water.

It should be noted that as in treating leather it is best to give three or four coats of colour liquor, the first coats (or baths) should be as weak as possible, as successive applications of colour in full strength give too dark a tint, and what is worse, they sometimes give a metallic hue that is objectionable.

It is not always the practice to brush the colour over morocco skins as just explained, for, as at first mentioned, the most even colouring is obtained by dipping. Morocco skins, however, are supposed to be coloured on one side only, therefore, for dipping, the ingenious plan of sewing two skins together by their edges, flesh side to flesh side, is adopted. This does not perfectly prevent some colour getting to the flesh side, but it does so sufficiently and few skins are seen without some colour on the wrong side. Those who are not practised at the work can do much to insure good results by passing an odd piece of skin, a cutting, through the process first.

In dealing with calf or kip leathers for boot uppers, for brown shades, a mordanting liquor is made by dissolving crystals of bichromate of potash in cold water. Some crystals are put in a pint of cold water and given an occasional shake, for one hour. The water is then poured off, and warm water added to it until it is a light straw tint. The skin is first moistened with this, and then, before it is quite dry, the dye liquor is applied. Should it dry too warm a tint, this can be reduced by a single application of the mordanting fluid. This latter is a topping agent or striker as already referred to. It needs to be used carefully and sparingly as tending to make the leather harsh and hard if used in excess.

Paper.—In dealing with small quantities the following plan may be adopted. Have a perfectly even and level table and spread the paper on this. Brush the stain on with a broad smooth brush. This is for colouring one side only. If both sides are to be coloured the paper must be submerged in the dye. Have the dye liquor in a shallow broad pan and draw the sheets through it horizontally. When the sheets are dry they can be smoothed by an iron or roll.

The following recipes for coloured papers are mainly derived from Dunbar, and give the quantity of pulp, and the material of which it is composed, in most cases.

Amber.—(1) For 400 lb. dry paper. 400 lb. Oran esparto, ½ lb. chrome yellow, mixed in the engine one hour; 1 pint iron liquor, 20 lb. alum, 6 pails size.

(2) Fine Amber Writings.—For 300 lb. dry paper. Medium Spanish esparto, ½.; F. F. rags, ¼; thirds, ¼; 6¼ oz. nitrate of lead, 3 oz. bichromate of potash, 11 oz. Venetian red strained through a silk bag, 30 lb. alum, 8 pails size.

Blue.—(1) Aniline Blue.—For 250 lb. dry paper. No. 4 stuff, full bleached; 5 pails size, 15 lb. alum, 3 oz. aniline blue, ⅛ oz. diamond fuchsine.

(2) Aniline Blue, deep shade.—For 250 lb. dry paper. No. 4 stuff, full bleached; 5 pails size, 20 lb. alum, 4 oz. aniline blue, ⅙ oz. diamond fuchsine.

(3) Deep Aniline Blue.—For 250 lb. dry paper. No. 3 stuff, full bleached; 6 pails size, 20 lb. alum, 4½ oz. aniline blue, ⅛ oz. diamond fuchsine.

(4) Aniline Blue, deep colour.—For 250 lb. dry paper. No. 4 stuff, full bleached; 4 pails size, 15 lb. alum, 2 oz. aniline blue, ⅙ oz. diamond fuchsine, 6 oz. Berlin blue.

(5) Deep Aniline Blue.—For 250 lb. dry paper. No. 4 stuff, full bleached; 5 pails size, 20 lb. alum, 9 lb. Paris blue, 3½ oz. aniline blue, 3 oz. diamond fuchsine. Presents a fine clear colour, very deep and uniform.

(6) Berlin Blue.—For 250 lb. dry paper. No. 4 stuff, half bleached; 5 pails size, 20 lb. alum, ½ oz. fuchsine, 5 lb. Paris blue.

(7) Blue Tissue.—For 200 lb. dry paper. Rope stuff, ½, good sailcloth, ½; 2 lb. ultramarine, B.B.A.C., 5 gills Brazil-wood dye.

(8) Fine Deep Blue.—For 400 lb. dry paper. 400 lb. Oran esparto; 1 lb. crystal soda, 10 lb. prussiate of potash, 3 lb. green copperas dissolved in 4 pails hot water, 4 qt. iron liquor, 1 oz. magenta dissolved in one pail of hot water, 25 lb. alum.

(9) Deep Paris Blue.—For 250 lb. dry paper. No. 4 stuff, half bleached; 4 pails size, 20 lb. alum, 2 lb. logwood extract, 6 lb. Berlin or Paris blue, 2 pints cochineal.

Brown.—(1) Soluble Brown.—For 250 lb. dry paper. No. 4 stuff, half bleached; 5 pails size, 20 lb. alum, 15 lb. soluble brown. This colouring matter must be carefully strained into the engine. It is the best substitute for catechu-dyed papers, and has all the characteristics of catechu, with the advantage of being much cheaper.

(2) Catechu Brown.—For 250 lb. dry paper. No. 4 stuff, unbleached; 4 pails size, 20 lb. alum, 12 pails catechu, 6 lb. bichromate, 3 lb. crystal soda.

(3) Catechu Brown.—For 250 lb. dry paper. No. 4 stuff, full bleached; 4½ lb. green copperas, 4 pails size,

3 pails catechu, 20 lb. alum, 3½ lb. bichromate.

(4) Catechu Brown, deep colour.—For 150 lb. dry paper. No. 4 stuff, unbleached; 3 pails size, 10 lb. alum, 3 pails catechu, 2 lb. green copperas, 3 lb. bichromate.

(5) Catechu Brown.—For 250 lb. dry paper. No. 4 stuff, half bleached; 4 pails size, 4 pails catechu, 20 lb. alum, 1½ lb. bichromate.

(6) Catechu Brown Wrapping.—For 250 lb. dry paper. Hemp bagging, ½; No. 4 stuff, ½; 7 pails catechu, 5 pails size, 15 lb. alum, 3 lb. bichromate.

Buff.—(1) For 250 lb. dry paper. No. 4 stuff; 60 lb. yellow wood, 4 pails size, 20 lb. alum, 13 lb. yellow ochre, 10 oz. Venetian red, 1 gill Brazil-wood dye.

(2) Light Buff.—For 400 lb. dry paper. 400 lb. Oran esparto, 4 lb. green copperas, 4 oz. sugar of lead, 3 lb. bichromate of potash, 15 lb. alum, 5 pails size.

Chocolate.—For 400 lb. dry paper. 500 lb. Oran esparto, 37 lb. Venetian red, 3 lb. catechu, 5 lb. bluestone, 5 lb. green copperas, 4 lb. ultramarine—all 1 hour apart; 20 lb. alum, 7 pails size.

Crowfoot Colour to Paper Pulp.—The colour of the crowfoot is one of the most agreeable in paper manufacture, but it is also very difficult to obtain in all the richness and brilliancy of the flower's hue. As in the case of many other colours for paper, the operation requires to be divided into two parts. With every 220 lb. of dry pulp the following process is observed: On the one hand, 26½ lb. acetate of lead are boiled separately in about 8 gal. water, and 8¾ lb. bichromate of potash in 4½ gal. water on the other. When the salts are completely dissolved, the same quantity of cold water is added to each solution as was used before; it is stirred, and the solution of acetate of lead is poured into that of the bichromate, the whole being stirred as the mixing takes place. The mixture is used in two separate basins or troughs, and produces the first colouring of the pulp. Supposing, as is to be expected, a uniform tint has been obtained, about 3½ pints of a yellow-orange colour are added, which is prepared in the following manner: 5½ gal. caustic soda lye, marking 20° B., are taken, to which are added 23 lb. acetate of lead, and 7½ lb. bichromate of potash, mixed dry, the whole being boiled for ¼ hour. From this are taken the 3½ pints mentioned above for the second colouring. ('La Gaceta Industrial.')

Fawn.—(1) For 250 lb. dry paper. No. 1 stuff; 4 pails size, 20 lb. alum, 2 lb. green copperas, 2 lb. crystal soda, 1½ lb. Venetian red.

(2) For 250 lb. dry paper. No. 4 stuff; 20 lb. chemical wood pulp, 5 oz. ultramarine, 1 lb. Venetian red, 4 lb. French yellow ochre.

Green.—(1) For 250 lb. dry paper. No. 4 stuff; 60 lb. mechanical wood pulp, 2½ lb. bichromate 15 minutes later, 6 lb. sugar of lead 15 minutes later, 7 oz. Paris blue, 4 pails size, 15 lb. alum.

(2) Medium Deep Shade.—For 250 lb. dry paper. No. 4 stuff; 60 lb. mechanical wood pulp, 5 pails size, 20 lb. alum, 2½ lb. bichromate 15 minutes later, 6 lb. sugar of lead 15 minutes later, 1½ lb. Paris blue.

(3) Deep Clear Tint.—For 250 lb. dry paper. No. 3 stuff; 1½ lb. bichromate, 3 lb. sugar of lead 15 minutes later, 3 lb. Paris blue 10 minutes later, 5 pails size, 20 lb. alum.

(4) Deep Green.—For 250 lb. dry paper. No. 3 stuff; 5 pails size, 20 lb. alum, 22 lb. silk green paste, extra fine. A beautiful clear green.

(5) Pale Green.—For 250 lb. dry paper. No. 4 stuff, full bleached; 60 lb. wood pulp, 3 oz. bichromate, 6 oz. sugar of lead, 4 pails size, 15 lb. alum, 3 lb. Paris blue.

(6) Pale Green.—For 250 lb. dry paper. No. 4 stuff, full bleached; 4 pails size, 20 lb. alum, ¾ lb. bichromate 10 minutes later, 2¼ lb. sugar of lead 10 minutes later, 15 oz. Paris blue dissolved in hot water, adding ½ gill sulphuric acid.

Grey.—(1) For 250 lb. dry paper. No. 4 stuff, half bleached; 4 pails size, 20 lb. alum, 3 lb. green copperas, 3 lb. crystal soda, 4 lb. dark yellow ochre, 4 lb. light yellow ochre, 5 oz. Venetian red.

(2) Fine Grey Writings.—For 250 lb. dry paper. No. 4 stuff, full bleached; 3 lb. ultramarine, B.B.R.V.; 2 lb. Venetian red, 4 lb. yellow ochre, 6 pails size, 20 lb. alum.

(3) Fine Grey Writings.—For 250 lb. dry paper. No. 4 stuff, full bleached; 6 pails size, 25 lb. alum, 15 oz. bichromate, 2½ lb. sugar of lead, 6 oz. Paris blue ½ hour later, 7 oz. logwood extract.

(4) Fine Grey Writings.—For 250 lb. dry paper. No. 4 stuff, full bleached; 6 pails size, 25 lb. alum, 12 oz. bichromate, 2 lb. sugar of lead, to be dissolved together in one pail, and put into the engine while hot; 3 oz. Paris blue ½ hour later, 4 oz. logwood extract.

(5) Superfine Grey Writings.—For 250 lb. dry paper. No. 3 stuff, full bleached; 4 lb. ultramarine, B.B.A.C.; 1 lb. bichromate, 1½ lb. sugar of lead, 3 lb. Venetian red, 6 pails size, 25 lb. alum.

Lilac.—(1) For 250 lb. dry paper. No. 4 stuff, full bleached; 5 pails size, 20 lb. alum, 3 oz. aniline blue, ½ oz. diamond fuchsine.

(2) Deep Lilac.—For 250 lb. dry paper. No. 3 stuff; 5 pails size, 20 lb. alum; 30 oz. methyl violet, marked B.B.B.; ½ oz. eosine, marked A.

(3) Deep Lilac.—For 250 lb. dry paper. Nos. 3 and 4 stuffs, half and half; 4 pails size, 15 lb. alum, 2 oz. aniline blue, 2 oz. diamond fuchsine, 3¾ oz. Paris blue.

(4) Deep Lilac.—For 250 lb. dry paper. No. 4 stuff, full bleached; 5 pails size, 20 lb. alum, 4 oz. aniline blue, 1 oz. diamond fuchsine.

(5) Deep Lilac.—For 250 lb. dry paper. No. 4 stuff; 20 lb. alum, 4 pails size, 8 oz. diamond fuchsine, 3 oz. aniline blue, 50 lb. straw pulp.

(6) Lilac Tissue.—Deep Shade. For 200 lb. dry paper. Nos. 17 and 18 rope stuffs, ½; No. 5 stuff, ½; 8 oz. aniline blue, 3 oz. diamond fuchsine, 2 oz. methyl violet, R.R.R.R. brand.

Nankeen Tissue.—For 200 lb. dry paper. Nos. 17 and 18 rope stuffs, ½; canvas, ½; 3 lb. potash, 3 lb. green copperas, 2 lb. crystal soda.

Olive, Deep.—For 250 lb. dry paper. No. 4 stuff; 60 lb. wood pulp, 4 pails size, 15 lb. alum, 2 lb. green copperas, 2 lb. crystal soda, 2¼ lb. Venetian red.

Orange.—(1) For 250 lb. dry paper. No. 4 stuff, only half bleached or gas-bleached, and not potched; 3 pails size, 15 lb. alum, 6 lb. bichromate, 8 lb. sugar of lead, 60 lb. superfine orange.

(2) For 250 lb. dry paper. No. 4 stuff; 50 lb. mechanical wood pulp, 12 lb. orange mineral, 15 lb. alum, 4 pails size.

(3) For 250 lb. dry paper. No. 4 stuff; 60 lb. mechanical wood pulp 15 lb. alum, 4 pails size, 30 lb. orange mineral.

(4) For 250 lb. dry paper. No. 4 stuff; 60 lb. mechanical wood pulp, 15 lb. alum, 3 pails size, 15 lb. orange mineral, 1 lb. Venetian red.

(5) For 200 lb. dry paper. No. 4 stuff; 50 lb. yellow mechanical wood pulp, 20 lb. orange mineral, 1½ lb. Venetian red, 4 pails size, 20 lb. alum. The orange and the Venetian red must be carefully strained through a fine wire or flannel bag.

(6) Orange Buff.—For 400 lb. dry paper. 400 lb. Oran esparto, 6 lb. bichromate of potash, 8 lb. sugar of lead, 14 lb. Venetian red, 20 lb. alum, 6 pails size.

(7) Chrome Orange.—For 300 lb. dry paper. No. 1 stuff, full bleached; 25 lb. alum, 6 pails size, 56 lb. chrome orange paste, No. 1. A fine clear orange for a good quality of paper.

(8) Deep Orange.—For 250 lb. dry paper. No. 4 stuff; 40 lb. wood pulp, 4 pails size, 20 lb. alum, 6 lb. bichromate, 18 lb. sugar of lead, 25 lb. Venetian red, 50 lb. straw pulp.

(9) Pale Orange. — For 250 dry paper. No. 4 stuff; 40 lb. wood pulp, 4 pails size, 15 lb. alum, 15 lb. superfine orange.

(10) Orange Yellow.—For 250 lb.

dry paper. No. 4 stuff; 40 lb. mechanical wood pulp, 3 pails size, 15 lb. alum, 6 lb. bichromate, 8 lb. sugar of lead, 25 lb. Venetian red, 50 lb. straw pulp.

(11) Orange Yellow.—For 400 lb. dry paper. 400 lb. Oran esparto; 7¼ lb. bichromato, 15 lb. brown sugar of lead, dissolved in 5 pails hot water—strain through a flannel bag; ¼ lb. Venetian red, 25 lb. alum, 7 pails size.

Pink.—(1) For 250 lb. dry paper. No. 4 stuff; 5 pails size, 20 lb. alum, 3 oz. diamond fuchsine, dissolved in 1⅞ gal. boiling water and strained through a fine flannel or silk bag.

(2) Eosine, A.—For 250 lb. dry paper. No. 3 stuff, full bleached; 13 oz. eosine, marked A; ¼ oz. methyl violet. A deep pink of a beautiful shade.

(3) Deep Eosine Pink.—For 250 lb. dry paper. No. 3 stuff; 5 pails size, 20 lb. alum, 12 oz. eosine, marked B.N., dissolved in boiling water, and strained through a flannel bag into the engine.

(4) Pale Pink Eosine.—For 250 lb. dry paper. No. 3 stuff; 5 pails size, 20 lb. alum, 3 oz. eosine, marked B.N., ¼ oz. methyl violet; strain into the engine.

Purple.—Water 1 qt., logwood 4 oz., Brazil-wood 1 oz. Boil together for a few hours, allow to cool, then strain.

Red.—(1) Deep Venetian.—For 200 lb. dry paper. No. 4 stuff, unbleached; 5 pails size, 20 lb. alum, 2¼ lb. yellow ochre, 50 lb. Venetian red, 3 pints Brazil-wood dye.

(2) Venetian Red.—For 250 lb. dry paper. No. 3 stuff, unbleached; 50 lb. chemical wood pulp, 4 pails size, 15 lb. alum, 60 lb. Venetian red, 3 pints Brazil-wood dye.

(3) Venetian Red.—For 250 lb. dry paper. No. 4 stuff, half bleached; 2½ lb. yellow ochre, 45 lb. Venetian red, 20 lb. alum, 5 pails size.

(4) Venetian Red.—For 250 lb. dry paper. No. 4 stuff; 40 lb. yellow wood pulp, 4 pails size, 15 lb. alum, 48 lb. yellow ochre, 50 lb. Venetian red. A beautiful deep Venetian red, principally used for the covers of serials.

(5) Saturnine Red.—For 250 lb. dry paper. No. 3 stuff; 4 pails size, 20 lb. alum, 50 lb. saturnine red, 5 lb. superfine orange.

Rose.—(1) For 400 lb. dry paper. 400 lb. Oran esparto, 14 lb. Venetian red, 1 lb. chrome yellow, 20 lb. alum.

(2) Fine Rose Tint.—For 400 lb. dry paper. Medium Spanish esparto, ½; good Oran esparto, ½; 2 oz. eosine, marked A, dissolved in one pail of boiling water and strained through a flannel bag.

Skin Colour.—For 250 lb. dry paper. No. 4 stuff, 60 lb. wood pulp, 4 pails size, 20 lb. alum, 9¼ lb. green copperas, 10½ lb. crystal soda, 8 oz. bichromate, 1½ lb. sugar of lead.

Straw Tint.—For 400 lb. dry paper. 400 lb. Oran esparto, 1½ lb. bichromate of potash, 3 lb. white sugar of lead dissolved in one pail of hot water, ¼ lb. ultramarine, 1½ pint iron liquor.

Violet.—Deep Shade.—For 250 lb. dry paper. No. 3 stuff, full bleached; 25 lb. alum, 5 pails size, 6 lb. methyl violet marked R.R.R.R., 3 oz. methyl blue.

White Tissue.—For 200 lb. dry paper. Nos. 17 and 18 rope stuffs, ½; No. 5 stuff, ½; 5 oz. ultramarine, B.B.A.C.; 2 gills Brazil-wood dye.

Yellow.—(1) For 250 lb. dry paper. No. 4 stuff; 4 lb. bichromate 20 minutes later, 8 lb. sugar of lead ½ hour later, 20 lb. alum, 6 pails size, 40 lb. straw pulp.

(2) For 250 lb. dry paper. No. 4 stuff; 15 lb. alum, 4 pails size, 1¼ lb. bichromate, 5 lb. sugar of lead.

(3) For 250 lb. dry paper. No. 4 stuff; 40 lb. mechanical wood pulp, 15 lb. alum, 4 pails size, 5 lb. bichromate, 8 lb. sugar of lead.

(4) For 250 lb. dry paper. No. 4 stuff; 20 lb. mechanical wood pulp, 2¼ lb. bichromate 20 minutes later, 7½ lb. sugar of lead ½ hour later, 20 lb. alum, 4 pails size.

(5) For 250 lb. dry paper. No. 4 stuff; 40 lb. mechanical wood pulp,

15 lb. alum, 4 pails size, 5 lb. bichromate, 11 lb. sugar of lead.

(6) Dark Yellow.—For 400 lb. dry paper. 14 lb. bichromate of potash, 1¾ lb. brown sugar of lead dissolved in one pail of hot water—strain into the engine through a flannel bag; 2¼ lb. green copperas 1 hour later, 25 lb. alum.

(7) Yellow Ochre, for Wrapping—For 250 lb. dry paper. No. 4 stuff, unbleached; 60 lb. wood pulp, No. 2 quality; 4 pails size, 15 lb. alum, 20 lb. yellow ochre, 5 oz. Venetian red, 4 oz. magenta lake.

(8) Yellow Printings.—For 250 lb. dry paper. No. 4 stuff, half bleached; 50 lb. mechanical wood pulp, 1¾ lb. bichromate 20 minutes later, ¾ lb. sugar of lead ½ hour later, 15 lb. alum, 3 pails size, 50 lb. straw pulp.

(9) For 450 lb. dry paper. Tunis esparto, ½; No. 2 Spanish esparto, ½; 20 lb. French ochre, 4 lb. dark English ochre, 8 lb. sugar of lead, 4½ lb. bichromate, 2 lb. red chrome.

(10) For 400 lb. dry paper. Tunis esparto, ½; Oran esparto, ½; 3½ lb. bichromate, 7 lb. sugar of lead.

(11) Fine Yellow Printings.—For 200 lb. dry paper. Spanish esparto, ½; Oran esparto, ½; 2 lb. bichromate, 4 lb. sugar of lead, 3 pails size, 10 lb. alum.

(12) Yellow Wrapping.—For 250 lb. dry paper. No. 4 stuff, unbleached; 50 lb. wood pulp, No. 2 quality; 4 pails size, 20 lb. alum, 16½ lb. brown sugar of lead, 8 lb. bichromate, 20 lb. Venetian red.

(13) Yellow Wrapping, for Post Paper.—For 250 lb. dry paper. No. 4 stuff; 60 lb. mechanical wood pulp, 2 lb. bichromate of potash 15 minutes later; 4 lb. sugar of lead, 20 lb. alum, 4 pails size, 50 lb. straw pulp by Lahosse's system.

(14) Lemon.—1 qt. spirits of wine, 3 oz. turmeric root. Bruise the root to a powder; put it into a bottle with the spirits of wine, cork soundly and shake frequently during 2 days. Strain and it is ready for use.

Parchment.—*Green.*—(*a*) Boil 8 parts cream of tartar and 30 of crystallised verdigris in 500 water; when this solution is cold, pour into it 4 parts nitric acid. Moisten the parchment with a brush, and then apply the above liquid evenly over its surface. The necessary surface finish is given with white of eggs, or mucilage of gum-arabic.

(*b*) 1 qt. vinegar, ¼ oz. verdigris. Boil together; apply with a soft brush and, when dry, wash over with a solution of pearlash and water, to bring up the required tint.

Blue.—(*a*) Dissolve verdigris in vinegar and brush over with the hot solution till it becomes a perfect green, then well brush over with a solution of pearlash, 2 oz. to the pint, until it becomes a good blue.

(*b*) Use the blue stain for wood, viz. copper filings dissolved in aquafortis; the material must be well brushed over with it, and then brushed over with a hot solution of pearlash, same strength as in (*a*), until it assumes a perfectly blue colour.

(*c*) Boil 1 lb. indigo, 2 lb. logwood, and 3 oz. of alum in 1 gal. of water; brush well over until thoroughly stained.

Red.—(*a*) Boil 1 lb. of Brazil-wood and 1 oz. of pearlash in 1 gal. of water, and while hot brush over the work until of a proper colour. Dissolve 2 oz. of alum in 1 qt. of water, and brush this solution over the above before it dries.

(*b*) Use a cold infusion of archil, and brush well over with a pearlash solution, 2 dr. to the qt.

Purple.—Water 2 qt., logwood ½ lb., Brazil-wood 2 oz. Boil together for a few hours, allow to cool, then strain.

Stone, Plaster, and Bricks.—If building stone, such as marble, limestones, etc., are to be stained, then, if water stains are to be used, the colours should be boiled in it. If possible the stain should be applied to the stone while boiling hot, and well brushed over the surfaces, and into any ornamental work. If a spirit stain is used, it should be applied cold, and in all cases be allowed to soak well in before any washing of the stone is attempted.

In colouring plaster a similar process can be adopted, but it is far better to mix dry colours (or liquid stains) when the plaster is first being mixed with water.

Bricks, which are usually stained or coloured a tint of red, can be treated with a solution made of ¼ lb. of glue in 4 gal. of water, to which is added ½ lb. alum, 2 lb. Venetian red, and 4 lb. Spanish brown. It should be tried before applying to a large surface, and the depth of red or brown can be varied by altering the quantities of those materials.

Wood.—The practice of staining woods is much less common in America and England than on the Continent, where workmen, familiar with the different washes, produce the most delicate tones of colour and shade. Wood is often stained to imitate darker and dearer varieties, but more legitimately to improve the natural appearance by heightening and bringing out the original markings, or by giving a definite colour without covering the surface and hiding the nature of the material by coats of paint. The best woods for staining are those of close even texture, as pear and cherry, birch, beech, and maple, though softer and coarser kinds may be treated with good effect. The wood should be dried, and if an even tint is desired, its surface planed and sandpapered. All the stains should, if possible, be applied hot, as they thus penetrate more deeply into the pores. If the wood is to be varnished, and not subjected to much handling, almost any of the brilliant mordants used in wool and cotton dyeing may be employed in an alcoholic solution; but when thus coloured it has an unnatural appearance, and is best used in small surfaces only, for inlaying, etc. The ebonised wood, of late years so much in vogue, is in many respects the most unsatisfactory of the stains, as the natural character and markings are completely blotted out, and it shows the least scratch or rubbing. Sometimes in consequence of the quality of the wood under treatment, it must be freed from its natural colours by a preliminary bleaching process. To this end it is saturated as completely as possible with a clear solution of 17½ oz. chloride of lime and 2 oz. soda crystals in 10½ pints water. In this liquid the wood is steeped for ½ hour, if it does not appear to injure its texture. After this bleaching it is immersed in a solution of sulphurous acid to remove all traces of chlorine, and then washed in pure water. The sulphurous acid, which may cling to the wood in spite of washing, does not appear to injure it, nor alter the colours which are applied.

Black.—(1) Obtained by boiling together blue Brazil-wood, powdered gall-apples, and alum, in rain or river water, until it becomes black. This liquid is then filtered through a fine organzine, and the objects painted with a new brush before the decoction has cooled, and this repeated until the wood appears of a fine black colour. It is then coated with the following liquid: A mixture of iron filings, vitriol, and vinegar is heated (without boiling), and left a few days to settle. Even if the wood is black enough, yet for the sake of durability, it must be coated with a solution of alum and nitric acid, mixed with a little verdigris; then a decoction of gall-apples and logwood dyes is used to give it a deep black. A decoction may be made of brown Brazil-wood with alum in rain-water, without gall-apples; the wood is left standing in it for some days in a moderately warm place, and to it merely iron filings in strong vinegar are added, and both are boiled with the wood over a gentle fire. For this purpose soft pear-wood is chosen. which is preferable to all others for black staining.

(2) 1 oz. nut-gall broken into small pieces, put into barely ½ pint vinegar, which must be contained in an open vessel; let stand for about ½ hour; add 1 oz. steel filings; the vinegar will then

commence effervescing; cover up, but not sufficient to exclude all air. The solution must then stand for about 2½ hours, when it will be ready for use. Apply the solution with a brush or piece of rag to the article, then let it remain until dry; if not black enough, coat it until it is, letting it remain sufficiently long to dry thoroughly each time. After the solution is made, keep it in a closely-corked bottle.

(3) 1 gal. water, 1 lb. logwood chips, ½ lb. black copperas, ½ lb. extract of logwood, ½ lb. indigo blue, 2 oz. lamp-black. Put these into an iron pot and boil them over a slow fire. When the mixture is cool, strain it through a cloth, add ¼ oz. nut-gall. It is then ready for use. This is a good black for all kinds of cheap work.

(4) 25 parts Campeachy wood, 200 water, and 3 sulphate of copper; the wood is allowed to stand 24 hours in this liquor, dried in the air, and finally immersed in nitrate of iron liquor at 4° B.

(5) Boil 8¾ oz. logwood in 70 oz. water and 1 oz. blue stone, and steep the wood for 21 hours. Take out, expose to the air for a good time, and then steep for 12 hours in a beck of nitrate of iron at 4° B. If the black is not deep enough, steep again in logwood liquor.

(6) It is customary to employ the clear liquid obtained by treating 2 parts powdered galls with 15 parts wine, and mixing the filtered liquid with a solution of iron protosulphate. Reimann recommends the use of water in the place of wine.

(7) Almost any wood can be dyed black by the following means: Take logwood extract such as is found in commerce, powder 1 oz., and boil it in 3½ pints of water; when the extract is dissolved, add 1 dr. yellow chromate of potash (not the bichromate), and agitate the whole. The operation is now finished, and the liquid will serve equally well to write with or to stain wood. Its colour is a very fine dark purple, which becomes a pure black when applied to the wood.

(8) For black and gold furniture, procure 1 lb. logwood chips, add 2 qt. water, boil 1 hour, brush the liquor in hot, when dry give another coat. Now procure 1 oz. green copperas, dissolve it in warm water, well mix, and brush the solution over the wood: it will bring out a fine black; but the wood should be dried outdoors, as the black sets better. If polish cannot be used, proceed as follows: Fill up the grain with black glue—i.e., thin glue and lamp-black—brushed over the parts accessible (not in the carvings); when dry paper down with fine paper. Now procure, say, a gill of French polish, in which mix 1 oz. of best ivory black, or gas black is best, well shake it until quite a thick pasty mass, procure ½ pint brown hard varnish, pour a portion into a cup, add enough black polish to make it quite dark, then varnish the work; two thin coats are better than one thick coat. The first coat may be glass-papered down where accessible, as it will look better. A coat of glaze over the whole gives a London finish. Enough varnish should be mixed at once for the job to make it all one colour. (Smither.)

(9) *For Table.*—Wash the surface of table with liquid ammonia, applied with a piece of rag; the varnish will then peal off like a skin; afterwards smooth down with fine sand-paper. Mix ¼ lb. lampblack with 1 qt. hot water, adding a little glue size; rub this stain well in; let it dry before sand-papering it; smooth again. Mind you do not work through the stain. Afterwards apply the following black varnish with a broad fine camel-hair brush: Mix a small quantity of gas-black with varnish. If one coat of varnish is not sufficient, apply a second one after the first is dry. Gas-black can be obtained by boiling a pot over the gas, letting the pot nearly touch the burner, when a fine jet black will form on the bottom, which remove, and mix with the varnish.

(10) 17·5 oz. Brazil-wood and 0·525 oz. alum are boiled for 1 hour in 2·75 lb. water. The coloured liquor is then

filtered from the boiled Brazil-wood, and applied several times boiling hot to the wood to be stained. This will assume a violet colour. This violet colour can be easily changed into black by preparing a solution of 2·1 oz. iron filings, and 1·05 oz. common salt in 17·5 oz. vinegar. The solution is filtered, and applied to the wood, which will then acquire a beautiful black colour.

(11) 8·75 oz. gall-nuts and 2·2 lb. logwood are boiled in 2·2 lb. rain-water for 1 hour in a copper boiler. The decoction is then filtered through a cloth, and applied several times while it is still warm to the article of wood to be stained. In this manner a beautiful black will be obtained.

(12) This is prepared by dissolving 0·525 oz. extract of logwood in 2·2 lb. hot rain-water, and by adding to the logwood solution 0·035 oz. chromate of potash. When this is applied several times to the article to be stained, a dark brown colour will first be obtained. To change this into a deep chrome-black, the solution of iron filings, common salt, and vinegar, given under (10) is applied to the wood, and the desired colour will be produced.

(13) Several coats of alizarine ink are applied to the wood, but every coat must be thoroughly dry before the other is put on. When the articles are dry, the solution of iron filings, common salt, and vinegar, as given in (10) is applied to the wood, and a very durable black will be obtained.

(14) According to Herzog, a black stain for wood, giving to it a colour resembling ebony, is obtained by treating the wood with two fluids, one after the other. The first fluid to be used consists of a very concentrated solution of logwood, and to 0·35 oz. of this fluid are added 0·017 oz. alum. The other fluid is obtained by digesting iron filings in vinegar. After the wood has been dipped in the first hot fluid, it is allowed to dry, and is then treated with the second fluid, several times if necessary.

Ebonising.—(1) Boil 1 lb. logwood chips 1 hour in 2 qt. water; brush the hot liquor over the work to be stained, lay aside to dry; when dry give another coat, still using it hot. When the second coat is dry, brush the following liquor over the work: 1 oz. green copperas to 1 qt. hot water, to be used when the copperas is all dissolved. It will bring out an intense black when dry. For staining, the work must not be dried by fire, but in the sunshine, if possible; if not, in a warm room, away from the fire. To polish this work first give a coating of very thin glue size, and when quite dry paper off very lightly with No. 0 paper, only just enough to render smooth, but not to remove the black stain. Then make a rubber of wadding about the size of a walnut, moisten the rubber with French polish, cover the whole tightly with a double linen rag, put one drop of oil on the surface, and rub the work with a circular motion. Should the rubber stick it requires more polish. Previous to putting the French polish on the wadding pledget, it ought to be mixed with the best drop black, in the porportion of ¼ oz. drop black to a gill of French polish. When the work has received one coat, set it aside to dry for about an hour. After the first coat is laid on and thoroughly dry, it should be partly papered off with No. 0 paper. This brings the surface even, and at the same time fills up the grain. Now give a second coat as before. Allow 24 hours to elapse, again paper off, and give a final coat as before Now comes "spiriting off." Great care must be used here, or the work will be dull instead of bright. A clean rubber must be made, as previously described, but instead of being moistened with polish it must be wetted with spirits of wine and placed in a linen rag screwed into a tight even-surfaced ball, just touched on the face with a drop of oil, and then rubbed lightly and quickly in circular sweeps all over the work from top to bottom. One application of spirits is usually enough, if sufficient has been placed on the rubber at the outset, but it is better to use rather too little than too much at a time, as an excess will entirely remove the polish, when the work will have to be polished again. Should this be the case, paper off at once, and commence as at first. It is the best way in the end. (Smither.)

(2) Lauber dissolves extract of logwood in boiling water until the solution indicates 0° Baumé; 5 pints of the solution is then mixed with 2½ pints pyroligneous iron mordant of 10°, and ½ pint acetic acid of 2°. The mixture is heated for ¼ hour, and is then ready for use.

(3) To imitate black ebony, first wet the wood with a solution of logwood and copperas, boiled together and laid on hot. For this purpose, 2 oz. logwood chips with 1½ oz. copperas, to 1 qt. water, will be required. When the work has become dry, wet the surface again with a mixture of vinegar and steel filings. This mixture may be made by dissolving 2 oz. steel filings in ½ pint vinegar. When the work has become dry again, sandpaper down until quite smooth. Then oil and fill in with powdered drop black mixed in the filler. Work to be ebonised should be smooth and free from holes, etc. The work may receive a light coat of quick-drying varnish, and then be rubbed with finely-pulverised pumice and linseed-oil until very smooth.

(4) 1 gal. strong vinegar, 2 lb. extract of logwood, ½ lb. green copperas, ¼ lb. China blue, and 2 oz. nut-gall. Put these in an iron pot, and boil them over a slow fire until they are well dissolved. When cool, the mixture is ready for use. Add to the above ½ pint iron rust, which may be obtained by scraping rusty hoops, or preferably by steeping iron filings in a solution of acetic acid or strong vinegar.

(5) Common ebony stain is obtained by preparing two baths; the first, applied warm, consists of a logwood decoction, to every quart of which 1 dr. alum is added; the second is a solution of iron filings in vinegar. After the wood has dried from the first, the second is applied as often as is required. For the first-named bath some substitute 16 oz. gall-nut, 4 oz. logwood dust, and 2 oz. verdigris, boiled in a sufficient quantity of water. A peculiar method of blackening walnut is in use in Nurnberg. On one of the Pegnitz Islands there is a large grinding-mill, turned by the stream, where iron tools are sharpened and polished. The wood is buried for a week or more in the slime formed by the wheels; when dug out it is jet black, and so permeated by silica as to be in effect petrified. Another way to ebonise flat surfaces of soft wood is to rub very fine charcoal-dust into the pores with oil. This works beautifully with the European linden and American whitewood.

(6) For a fine black ebony stain, apple, pear, and hazel wood are the best woods to use; when stained black, they are most complete imitations of the natural ebony. For the stain take—gall-apple, 14 oz.; rasped logwood, 3½ oz.; vitriol, 1¾ oz.; verdigris, 1¾ oz. For the second coating a mixture of iron filings (pure), 3½ oz., dissolved in strong wine vinegar; 1½ pint is warmed, and when cool the wood already blackened is coated 2 or 3 times with it, allowing it to dry after each coat. For articles which are to be thoroughly saturated, a mixture of 1¾ oz. sal-ammoniac, with a sufficient quantity of steel filings, is to be placed in a suitable vessel, strong vinegar poured upon it, and left for 14 days in a gently-heated oven. A strong lye is now put into a suitable pot, to which is added coarsely-bruised gall-apples and blue Brazil shavings, and exposed for the same time as the former to the gentle heat of an oven, which will then yield a good liquid. The woods are now laid in the first-named stain, boiled for a few hours, and left in it for 3 days longer; they are then placed in the second stain and treated as in the first. If the articles are not then thoroughly saturated, they may be once more placed in the first bath, and then in the second. The polish used for wood

that is stained black should be "white" (colourless) polish, to which a very little finely-ground Prussian blue should be added.

(7) Wash with a concentrated aqueous solution of extract of logwood several times; then with a solution of acetate of iron of 14° B., which is repeated until a deep black is produced.

(8) Beech, pear-tree, or holly steeped in a strong liquor of logwood or galls. Let the wood dry, and wash over with solution of sulphate of iron. Wash with clean water, and repeat if colour is not dark enough. Polish with black polish.

(9) Oak is immersed for 48 hours in a hot saturated solution of alum, and then brushed over several times with a logwood decoction prepared as follows: Boil 1 part best logwood with 10 of water, filter through linen, and evaporate at a gentle heat until the volume is reduced one-half. To every quart of this add 10 to 15 drops of a saturated solution of indigo, completely neutral. After applying this dye to the wood, rub the latter with a saturated and filtered solution of verdigris in hot concentrated acetic acid, and repeat the operation until a black of the desired intensity is obtained. Oak thus stained is said to be a close as well as handsome imitation of ebony.

(10) 1 lb. logwood chips, 3 pints water; boil to 1 pint; apply hot to wood; let dry; then give another coat; let dry slowly; sandpaper smooth; mix 1 gill vinegar with 3 tablespoonfuls iron or steel filings; let stand 5 hours, then brush on wood; let dry; then give another coat of the first. This sends the vinegar deeper into the wood and makes a denser black; after which paper smooth. Then polish with white French polish, as the white brings out the black purer than common French polish. The woods observed to take on the stain best are pear-tree, plane-tree, and straight-reeded birch; mahogany does not stain nearly so well as the former woods.

(11) Get 1 lb. of logwood chips and boil them down in enough water to make a good dark colour; give the furniture 3 or 4 coats with a sponge; then put some rusty nails or old iron into a bottle with some vinegar, and when it begins to work give the furniture a coat of the vinegar. This, if you have well darkened it with the first, will give you a good black. Oil and polish in the usual way, rubbing down first with fine paper if required. A quicker way is to give the wood a coat of size and lampblack, and then use gas-black in your polish rubber.

(12) Make a strong decoction of logwood by boiling 1 lb. in 1 qt. water for about 1 hour; add thereto a piece of washing soda as large as a hazel-nut. Apply hot to the wood with a soft brush. Allow to dry, then paint over the wood with a solution of sulphate of iron (1 oz. to the pint of water). Allow this to dry, and repeat the logwood and sulphate of iron for at least three times, finishing off with logwood. Once more allow to dry thoroughly, then sandpaper off very lightly (so as not to remove the dye) with No. 0 paper. Now make a very thin glue size, boil in it a few chips of logwood and a crystal or two of sulphate of iron, just sufficient to make it inky black. Paint this lightly over the work, allow to dry once more, again sandpaper lightly, and finally either varnish with good hard white varnish, or polish with French polish and drop black.

Blue.—(1) Powder a little Prussian blue, and mix to the consistency of paint with beer; brush it on the wood, and, when dry, size it with glue dissolved in boiling water; apply lukewarm, and let this dry also; then rub down and varnish or French polish.

(2) Indigo solution, or a concentrated hot solution of blue vitriol, followed by a dip in a solution of washing soda.

(3) Prepare as for violet, and dye with aniline blue.

(4) A beautiful blue stain is obtained by gradually stirring 0·52 oz. finely powdered indigo into 4·2 oz. sulphuric acid of 60 per cent., and by exposing this mixture for 12 hours to a temperature of 77° F. (25° C.). The mass

is then poured into 11 to 13 lb. rain-water, and filtered through felt. This filtered liquor is applied several times to the wood, until the desired colour has been obtained. The more the solution is diluted with water, the lighter will be the colour.

(5) 1·05 oz. finest indigo carmine, dissolved in 8·75 oz. water, applied several times to the articles to be stained. A very fine blue is in this manner obtained.

(6) 3·5 oz. French verdigris are dissolved in 3·5 oz. urine and 8·75 oz. wine vinegar. The solution is filtered and applied to the article to be stained. Then a solution of 2·1 oz. carbonate of potash in 8·75 oz. rain-water is prepared, and the article coloured with the verdigris is brushed over with this solution until the desired blue colour makes its appearance.

(7) The newest processes of staining wood blue are those with aniline colours. The following colours may be chosen for the staining liquor: Bleu de Lyon (reddish blue), bleu de lumière (pure blue), light blue (greenish blue). These colours are dissolved in the proportion of 1 part colouring substance to 30 of spirits of wine, and the wood is treated with the solution.

Brown.—(1) Various tones may be produced by mordanting with chromate of potash, and applying a decoction of fustic, of logwood, or of peachwood.

(2) Sulphuric acid, more or less diluted according to the intensity of the colour to be produced, is applied with a brush to the wood, previously cleaned and dried. A lighter or darker brown stain is obtained, according to the strength of the acid. When the acid has acted sufficiently, its further action is arrested by the application of ammonia.

(3) Tincture of iodine yields a fine brown coloration, which, however, is not permanent unless the air is excluded by a thick coating of polish.

(4) A simple brown wash is ½ oz. alkanet root, 1 oz. aloes, 1 oz. dragon's-blood, digested in 1 lb. alcohol. This is applied after the wood has been washed with aqua regia, but is like all the alcoholic washes, not very durable.

Brown for Oak Picture-Frames.—(1) Dissolve 1 oz. of bichromate of potash in 1 qt. of rain-water, and add sufficient dry burnt umber for the required shade. For a darker tint substitute Vandyke brown for the umber. Apply liberally with brush or rag in the direction of the grain. The potash has a darkening effect without the colouring matters, so trial should be made on odd pieces of wood.

Browns for old Oak.—(1) In repairing old furniture any new material must be stained to match the old. There appears to be no better way of doing this than using a simple solution of permanganate of potash in water. The depth of colour can be tried on any spare cuttings.

(2) When old oak is to be made of a deeper shade, iron wash is used. This is made by pouring some vinegar over scrap iron, which, after a few hours, will make a liquid with which old oak can be stained to the deepest shade. It is not suited for new oak as it gives a purplish shade with this, but it suits old (or fumed new) wood well.

Green.—(1) Mordant the wood with red liquor at 1° B. This is prepared by dissolving separately in water 1 part sugar of lead and 4 of alum free from iron; mix the solutions, and then add $\frac{1}{32}$ part of soda crystals, and let settle overnight. The clear liquor is decanted off from the sediment of sulphate of lead, and is then diluted with water till it marks 1° B. The wood, when mordanted, is dyed green with berry liquor and extract of indigo, the relative proportions of which determine the tone of the green.

(2) Verdigris dissolved in 4 parts water; or in vinegar.

(3) 4·2 oz. copper, cut up finely, are gradually dissolved in 13 oz. nitric acid (aquafortis), and the articles to be stained are boiled in this solution until they have assumed a fine green colour.

Grey.—(1) Greys may be produced by boiling 17 oz. orchil paste for ½ hour in 7 pints water. The wood is first treated with this solution, and then, before it is dry, steeped in a beck of nitrate of iron at 1° B. An excess of iron gives a yellowish tone; otherwise a blue grey is produced, which may be completely converted into blue by means of a little potash.

(2) 1 part nitrate of silver dissolved in 50 of distilled water; wash over twice; then with hydrochloric acid, and afterwards with water of ammonia. The wood is allowed to dry in the dark, and then finished in oil and polished.

(3) An artistic grey-green: Brush the wood over with a solution of 1 part of pyrogallic acid in 20 of water. When dry go over with a solution of 1 part of aniline green in 12 of alcohol.

(4) ½ lb. verdigris, 1 oz. sap green, 1 oz. indigo, 3 qt. vinegar. Wash the wood with the hot liquor, or boil the wood in it.

(5) Dark green-blue for oak. Wash over with copperas in water.

(6) Green-grey for maple. Wash over with copperas in water.

Mahogany.—(1) Boil ½ lb. madder and 2 oz. logwood chips in 1 gal. water, and brush well over while hot. When dry, go over with pearlash solution, 2 dr. to the quart. By using it strong or weak, the colour can be varied at pleasure.

(2) Soak 1 lb. stick varnish in 2 qt. water until all the colour is dissolved out; strain off the water, and add to the residue 25 dr. powdered madder. Set the mixture over the fire until it is reduced to ⅔ of its original volume. Then mix together 25 dr. cochineal, 25 dr. kermes berries, 1 pint spirits of wine, and ½ oz. pearlash, out of which the colour has been washed by soaking in a gill of soft water. Add this mixture to the decoction of madder and varnish, stirring well together, and adding so much aquafortis as will bring the red to the desired shade. (Gewerbehalle.)

(3) Dark Mahogany. — Introduce into a bottle 15 gr. alkanet root, 30 gr. aloes, 30 gr. powdered dragon's-blood, and 500 gr. 95 per cent. alcohol, closing the mouth of the bottle with a piece of bladder, keeping it in a warm place for 3 or 4 days, with occasional shaking, then filtering the liquid. The wood is first mordanted with nitric acid, and when dry washed with the stain once or oftener, according to the desired shade; then, the wood being dried, it is oiled and polished.

(4) Light Mahogany.—Same as dark mahogany, but the stain being only applied once. The veins of true mahogany may be imitated by the use of acetate of iron skilfully applied.

(5) The following process is recommended in 'Wiederhold's Trade Circular': The coarse wood is first coated with a coloured size, which is prepared by thoroughly mixing up, in a warm solution, 1 part commercial glue in 6 of water, and a sufficient quantity of commercial mahogany brown, which is in reality an iron oxide, and in colour stands between so-called English red and oxide of iron. This is best effected by adding in excess a sufficient quantity of the dry colour with the warm solution of glue, and thoroughly mixing the mass by means of a brush until a uniform paste is obtained, in which no more dry red particles are seen. A trial coat is then laid upon a piece of wood. If it is desired to give a light mahogany colour to the object, it is only necessary to add less, and for a darker colour more, of the brown body-colour. When the coat is dry, it may be tested, by rubbing with the fingers, whether the colour easily separates or not. In the former case, more glue must be added until the dry trial coat no longer perceptibly rubs off with the hands. Having ascertained in this way the right condition of the size colour with respect to tint and strength, it is then warmed slightly, and worked through a hair sieve by means of a brush. After this, it is rubbed upon the wood surface with the brush, which has been carefully washed. It is not necessary to keep the colour warm during the painting. Should it become thick by

gelatinising, it may be laid on the wood with the brush, and dries more rapidly than when the colour is too thin. If the wood is porous and absorbs much colour, a second coat may be laid on the first when dry, which will be sufficient in all cases. On drying, the size colour appears dull and unsightly, but the following coat changes immediately the appearance of the surface. This coat is spirit varnish. For its production 3 parts spirits of wine of 90° are added in excess to 1 part of red acaroid resin in one vessel, and in another 10 parts shellac with 40 of spirits of wine of 80°. By repeated agitation for 3 or 4 days the spirit dissolves the resin completely. The shellac solution is then poured carefully from the sediment, or, better still, filtered through a fine cloth, when it may be observed that a slight milky turbidity is no detriment to its use. The resin solution is best filtered into the shellac solution by pouring through a funnel loosely packed with wadding. When filtered, the solutions of both resins are mixed by agitating the vessel and letting the varnish stand a few days. The acaroid resin colours the shellac, and imparts to it at the same time the degree of suppleness usually obtained by the addition of Venetian turpentine or linseed-oil. If the varnish is to be employed as a coat, the upper layers are poured off at once from the vessel. One or two coats suffice, as a rule, to give the object an exceedingly pleasing effect. The coats dry very quiokly, and care must be taken not to apply the second coat until the first is completely dry.

(6) 7·5 oz. madder, 8·75 oz. rasped yellow wood, are boiled for 1 hour in 5·5 lb. water, and the boiling liquor is applied to the articles until the desired colour has been produced.

(7) 1·05 oz. powdered turmeric 1·05 oz. powdered dragon's-blood, are digested in 8·75 oz. of 80 per cent. strong alcohol, and when the latter seems to be thoroughly coloured it is filtered through a cloth. The filtrate is heated and applied warm to the article.

(8) 17·5 oz. madder, 8·75 oz. ground logwood, are boiled for 1 hour in 5·5 lb. water. This is filtered while still warm, and the warm liquor is applied to the wood. When this has become dry, and it is desired to produce a darker mahogany colour, a solution of 0·525 oz. carbonate of potash in 4·4 lb. water is applied to the wood. This solution is prepared cold, and filtered through blotting-paper.

(9) 0·35 oz. red aniline is dissolved in 8·75 oz. spirits of wine 90 per cent. strong. Then another solution of 0·35 oz. aniline yellow in 17·5 oz. spirits of wine 90 per cent. strong is made, and this is added to the aniline solution until the required reddish-yellow colour is obtained. By adding a little of a solution of aniline brown (0·35 oz. aniline brown in 10·5 oz. spirits of wine 90 per cent. strong), the colour is still more completely harmonised, and a tint very closely resembling mahogany can be given to elm and cherry wood with this mixture.

(10) 0·7 oz. logwood is boiled in 3·5 oz. water down to about ½. This is then filtered, and 0·12 oz. chloride of baryta is dissolved in it.

(11) *Chippendale.*—Take mahogany stain and darken it by a solution of bichromate of potash. A pennyworth of the latter is sufficient for a pint of water. Its strength can be tested on an odd piece of new wood. More water can be added if necessary.

Maple.—2 gal. methylated spirits, ½ lb. gamboge, 6 lb. pale button lac, ½ oz. Bismarck brown, 1 oz. Vandyke brown.

Oak.—Mix powdered ochre, Venetian red, and umber, in size, in proportions to suit; or a richer stain may be made with raw sienna, burnt sienna, and Vandyke brown. A light yellow stain of raw sienna alone is very effective.

Darkening Oak.—(1) Lay on liquid ammonia with a rag or brush. The colour deepens immediately, and does not fade, this being an artificial production of the process which is induced naturally by age. Bichromate of potash, dissolved in cold water and applied in a like manner, will produce a very similar result.

(2) In Germany, the cabinet-makers use very strong coffee for darkening oak. To make it very dark: iron filings with a little sulphuric acid and water, put on with a sponge, and allowed to dry between each application until the right hue is reached.

(3) Whitewash with fresh lime, and when dry brush off the lime with a hard brush, and dress well with linseed-oil. It should be done after the wood has been worked, and it will make not only the wood, but the carving or moulding, look old also.

(4) Use a strong solution of common washing-soda, say one or two coats, until the proper colour is obtained. Or you may try carbonate of potash. Paper and finish off with linseed-oil.

(5) A decoction of green walnut-shells will bring new oak to any shade, or nearly black.

Purple.—(1) Take 1 lb. logwood chips, ¾ gal. water, 4 oz. pearlash, 2 oz. powdered indigo. Boil the logwood in the water till the full strength is obtained, then add the pearlash and indigo, and when the ingredients are dissolved the mixture is ready for use, either warm or cold. This gives a beautiful purple.

(2) To stain wood a rich purple or chocolate colour, boil ½ lb. madder and ¼ lb. fustic in 1 gal. water, and when boiling brush over the work until stained. If the surface of the work should be perfectly smooth, brush over with a weak solution of nitric acid, then finish with the following: Put 4½ oz. dragon's-blood and 1 oz. soda, both well bruised, into 3 pints spirits of wine. Let it stand in a warm place, shake frequently, stain and lay on with a soft brush, repeating until a proper colour is gained. Polish with linseed-oil or varnish.

(3) 2·2 lb. rasped logwood and 5·5 lb. rasped Lima red dyewood are boiled for 1 hour in 5·5 lb. water. It is then filtered through a cloth and applied to the article to be stained until the desired colour has been obtained. In the meanwhile a solution of 0·175 oz. carbonate of potash in 17·5 oz. water has been prepared, and a thin coat of this is applied to the article stained red. But strict attention must be paid not to apply too thick a coat of this solution, or else a dark blue colour will be the result.

Red.—(1) The wood is plunged first in a solution of 1 oz. of curd soap in 35 fl. oz. water, or else is rubbed with the solution; then magenta is applied in a state of sufficient dilution to bring out the tone required. All the aniline colours behave very well on wood.

(2) For a red stain, a decoction of ¼ lb. logwood and ¼ oz. potash in 1 lb. water is used as the bath, being fixed by a wash of alum water. For scarlet, use 1 oz. cochineal, 6 oz. powdered argol, 4 oz. cream tartar, in 12 oz. chloride of tin (scarlet spirits).

(3) Take 1 qt. alcohol, 3 oz. Brazil-wood, ½ oz. dragon's-blood, ½ oz. cochineal, 1 oz. saffron. Steep to full strength and strain. It is a beautiful crimson stain for violins, work-boxes, and fancy articles.

(4) Besides the aniline colours, which are, however, much affected by sunlight, cochineal gives a very good scarlet red upon wood. Boil 2 oz. cochineal, previously reduced to a fine powder, in 35 oz. water for 3 hours, and apply it to the wood. When dry, give it a coating of dilute chloride of tin to which is added a little tartaric acid—1 oz. chloride of tin, and ½ oz. tartaric acid in 35 fl. oz. water. If, instead of water, the cochineal is boiled in a decoction of bark (2 oz. bark to 35 oz. water), and the chloride of tin is used as above, an intense scarlet and all shades of orange may be produced according to the proportions.

(5) Take 1 gal. alcohol, 1⅓ lb. camwood, ½ lb. red sanders, 1 lb. extract of logwood, 2 oz. aquafortis. When dissolved, it is ready for use. It should be applied in 3 coats over the whole sur-

face. When dry, rub down to a smooth surface, using for the purpose a very fine paper. The graining is done with iron rust, and the shading with asphaltum thinned with spirits of turpentine. When the shading is dry, apply a thin coat of shellac; and when that is dry, rub down with fine paper. The work is then ready for varnishing—a fine rose tint.

(6) Monnier recommends steeping the wood for several hours in a bath of 1200 gr. iodide of potassium to the quart of water, and then immersing it in a bath of 375 gr. corrosive sublimate, when it will assume a beautiful rose-red colour by chemical precipitation. It should subsequently be covered with a glossy varnish. The baths will not need renewal for a long time.

(7) 2·2 lb. finely-powdered Lima red dyewood and 2·1 oz. carbonate of potash are put in a glass bottle and digested in 5·5 lb. water for 8 days in a warm place; the bottle should be frequently shaken. It is then filtered through a cloth; the fluid is heated, and applied to the article to be stained until the latter acquires a beautiful colour. If it is desired to brighten the colour, a solution of 2·1 oz. alum, free from iron, in 2·2 lb. water is applied to the article while it is still wet. The last solution can be prepared by heat; when it has been accomplished, it is filtered. As soon as the stains have become dry, they should be rubbed with a rag moistened with linseed-oil, after which the varnish may be applied.

(8) Cherry.—3 qt. of water, ¼ lb. annatto; boil together in a copper vessel until dissolved. Now add a piece of potash about the size of a walnut, and boil for 30 minutes longer.

(9) Superior Cherry.—Use common Munich lake. This produces a beautiful rich cherry shade.

(10) Cherry for Common Work.—Dissolve common dark yellow ochre in water and add a little old beer. Apply one coat. When dry, rub down with fine glass-paper and then go over with a coat of red lake ground in water.

(11) Rose.—Iodide of potash in 12 parts water for a first coat, and corrosive sublimate in 20 parts water for a second.

(12) Crimson.—1 lb. ground Brazil-wood, ¾ gal. water, ½ oz. cochineal. Boil the Brazil-wood for an hour, strain and add the cochineal; boil gently for 30 minutes and it is ready for use.

Rosewood.—(1) In 3 qt. of water boil 1 lb. of logwood until a dark red colour is obtained, then add 1 oz. of salts of tartar. Give the wood 3 or 4 coats while the liquid is scalding hot, letting each coat dry. If desired, this can be grained with black stain, if a good imitation of real rosewood is required.

Satinwood.—Take 1 qt. alcohol, 3 oz. ground turmeric, 1½ oz. powdered gamboge. When steeped to its full strength, strain through fine muslin. It is then ready for use. Apply with a piece of fine sponge, giving the work 2 coats. When dry, sandpaper down very fine. It is then ready for polish or varnish, and is a good imitation of satinwood.

Violet.—(1) The wood is treated in a bath made up with 4½ oz. olive-oil, the same weight of soda-ash, and 2½ pints boiling water, and it is then dyed with magneta to which a corresponding quantity of tin crystals has been added.

(2) 1 lb. Brazil-wood, ¾ oz. alum, 2½ pints water. Boil together and strain. Apply 3 or 4 coats while boiling hot, letting each coat dry.

Walnut.—Deal and other common woods are stained to imitate polished walnut in various ways.

(1) One method is, after careful rubbing with glasspaper, to go over the surface with a preparation of Cassel brown boiled in a lye of soft soap and soda. After drying, the surface is rubbed over with pumice and oil, and polished with shellac. The Cassel brown will not take equally well on all kinds of wood, so that if not laid on thick it sometimes comes off under the subsequent pumicing; whilst on the other hand this same

thickness conceals, more or less, the grain on the wood beneath, giving it the appearance of having been painted.

(2) Others use instead a decoction of green walnut-shells, dried and boiled in the same lye, or in soft water to which soda has been added. The decoction of walnut-shells is apt to come off on the clothes as a yellowish adhesive substance.

(3) Others, again, employ catechu and bichromate of potash in equal parts, boiled separately and afterwards mixed. The mixture of catechu and bichromate of potash leaves a reddish-brown deposit on the surface of the wood, not unlike real walnut.

(4) The following is said to be a very superior method for staining any kind of wood in imitation of walnut, while it is also cheap and simple in its manipulation. The wood, previously thoroughly dried and warmed, is coated once or twice with a stain composed of 1 oz. extract of walnut-peel dissolved in 6 oz. soft water by heating it to boiling, and stirring. The wood thus treated, when half dry, is brushed with a solution of 1 oz. bichromate of potash in 5 oz. boiling water, and is then allowed to dry thoroughly, and is to be rubbed and polished as usual. Red beech and alder, under this treatment, assume a most deceptive resemblance to American walnut. The colour is fixed in the wood to a depth of one or two lines.

(5) Mix dragon's-blood and lampblack in methylated spirits till you get the colour required, and rub it well into the grain of the wood.

(6) Light Walnut.—Dissolve 1 part permanganate of potassium in 30 of pure water, and apply twice in succession; after an interval of 5 minutes, wash with clean water, and when dry, oil and polish.

(7) Dark Walnut.—Same as for light walnut, but after the washing with water the dark veins are made more prominent with a solution of acetate of iron.

(8) In the winter season get some privet berries (black), which grow in most gardens, and put 2 oz. in ½ pint solution of liquid ammonia. This, applied to pine, then varnished or polished, cannot be detected from real walnut itself.

(9) Take 1 gal. very thin sized shellac; add 1 lb. dry burnt umber, 1 lb. dry burnt sienna, and ¼ lb. lampblack. Put these articles into a jug and shake frequently until they are mixed. Apply one coat with a brush. When the work is dry, rub down with fine paper, and apply one coat of shellac or cheap varnish. It will then be a good imitation of solid walnut, and will be adapted for the back boards of mirror-frames, for the back and inside of casework, and for similar work.

(10) Take 1 gal. strong vinegar, 1 lb. dry burnt umber, ½ lb. fine rose-pink, ½ lb. dry burnt Vandyke brown. Put into a tin and mix well; let the mixture stand one day, and it will then be ready for use. Apply this stain to the wood with a piece of fine sponge; it will dry in ½ hour. The whole piece is then ready for the filling process. When the work is completed, the stained part cannot be detected even by those who have performed the job. By means of this recipe, wood of poor quality and mostly of sap can be used with good effect.

(11) By a simple staining, furniture of pine or birch wood can be easily made to appear as if it had been veneered with walnut veneer. For this a solution of 3·15 oz. manganate of potash, and 3·15 oz. sulphate of manganese in 5·25 qt. hot water, is made. This solution is applied to the wood with a brush, and must be repeated several times. The manganate of potash is decomposed when it comes in contact with the woody fibre, and thus a beautiful and very durable walnut colour is obtained. If small wooden articles are to be stained in this manner a very diluted bath is prepared; the articles are dipped into it, and kept there 1 to 9 minutes according as the colour is desired lighter or darker.

(12) *Darkening Walnut.*—Slaked lime, 1 to 4 of water, will do for some

kinds of walnut; a weak solution of sulphate of iron for others; and yet again for other kinds a weak solution of pearl-ash. Try each on the wood, and choose the one you like best.

(13) To give to walnut a dark colour resembling rosewood, Hirschberg uses a solution 0·17 oz. bichromate of potash in 1·05 oz. water. This solution is applied to the walnut with a sponge, and the wood is then pumiced and polished.

Yellow. — (1) Mordant with red liquor, and dye with bark liquor and turmeric.

(2) Turmeric dissolved in wood naphtha.

(3) Aqua regia (nitro-muriatic acid), diluted in 3 parts water, is a much-used though rather destructive yellow stain.

(4) Nitric acid gives a fine permanent yellow, which is converted into dark brown by subsequent application of tincture of iodine.

(5) Wash over with a hot concentrated solution of picric acid, and when dry, polish the wood.

(6) 0·5 oz. nitric acid (aquafortis) is compounded with 1·57 oz. rainwater, and the article to be stained is brushed over with this. Undiluted nitric acid gives a brownish-yellow colour.

(7) 2·1 oz. finely-powdered turmeric are digested for several days in 17·5 oz. alcohol 80 per cent. strength, and then strained through a cloth. This solution is applied to the articles to be stained. When they have become entirely dry, they are burnished and varnished.

(8) 1·57 oz. carbonate of potash are dissolved in 4·2 oz. rain-water. This solution is poured over 0·52 oz. annatto, and this mixture is allowed to stand for 3 days in a warm place, being frequently shaken in the meanwhile. It is then filtered, and 0·175 oz. spirit of sal-ammoniac is added to it. The stain is now ready, and the articles to be stained will acquire a very beautiful bright yellow colour by placing them in it.

(9) Bright Golden Yellow. — 0·52 oz. finely-powdered madder is digested for 12 hours with 2·1 oz. diluted sulphuric acid, and then filtered through a cloth. The articles to be stained are allowed to remain in this fluid 3 to 4 days, when they will be stained through.

(10) Orange Yellow.—½ lb. orange shellac, 3 pints methylated spirits, 1 oz. pearl ash, ½ oz. dragon's-blood.

Fumigating (or Ammoniaising) Oak. —This process is adopted to give oak wainscot or other work an antique appearance. The tint obtained is very good, but it does not penetrate the wood deeper than a stain. Obtain some liquid ammonia of 880° strength (specific gravity). Arrange that the wood to be treated be so stacked that the ammonia fumes may get to all the parts or surfaces that need tinting. The wood must be arranged in a dark and air-tight room, or in a soundly closing box if this is large enough for the wood. The ammonia is then poured into one or more earthenware plates, or dishes, according to the size of the room, and placed on the floor. The apartment is then closed, and it is best if all cracks have paper pasted over them. The ammonia must not touch the oak; it is the fumes only that do the work, acting on the tannic acid and browning it. The depth of shade will depend on the time allowed and the amount of ammonia exposed, but in all cases the colour goes in deep enough to admit of a thin shaving being removed, if necessary, without showing the light wood beneath.

Darkening the Natural Tint of Woods. —Make a solution of equal parts of manganate of soda and crystallised Epsom salts, dissolved in 20 to 25 times the bulk of water at about 145° F. The more water used the lighter the effect, while by lessening the water the tint will be darker. The wood is simply brushed over with this solution.

* * *

THE "STEAM LOOP."

THIS peculiar device—an arrangement of piping really—was introduced with the view to having condense water automatically delivered into a steam boiler, although the water is first collected at a point below the boiler level. Fig. 130 shows the scheme of piping, and will serve to describe its action. The boiler will be seen on the right, a steam supply main leaving its top as usual. It is supposed in this instance that the supply main has to drop below the water level, then rise to a fair amount of work, so that condense water gathers at B in some volume. In the ordinary way it would be discharged by a trap, but in this case the steam loop is used to carry it back into the boiler. It may be here mentioned that no check or stop valves are needed in the loop to make it act; they are only put in when the fitter considers they will serve some special purpose.

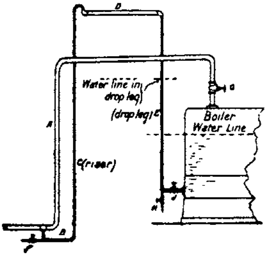

FIG. 130.

From the point B, where the water collects, a connection is made and the riser C taken up in the manner shown. This riser can be any size from ¾ in. to 2 in., according to the amount of water to be dealt with. At a required height (which will be understood directly), this riser dips down and is connected to a larger sized horizontal pipe D. If the riser was 1¼ in. pipe, the horizontal could be 2¼ in. From the horizontal a drop-pipe or drop-leg, is carried down to boiler and enters below the water line. This is all there is of the steam loop, merely some 30 ft. of pipe and fittings.

Supposing the pressure in the boiler was 20 lb. and the pressure at B 18 lb. then the water column in drop leg E would rise nearly 5 ft.* to obtain a balance of pressure, an equilibrium in the loop. The equilibrium, however, is constantly being disturbed by the fact that steam condenses in the riser C and particularly in the horizontal D, tending to make a vacuum, and exerting a pull on the contents of the two vertical pipes. The pull is equal on both pipes, and were their contents the same, the apparatus would fail, but in one pipe is steam and in the other water, and the steam fills the space every time, as fast as the condensing steam makes the vacancy.

The consequence of this is that the quick flow of steam up the riser carries the condense water with it as a spray or scud, and the action seen through a section of glass tube (in the riser of a practical loop) gave the appearance of an irregular rain of water, which, however, rains upwards instead of downwards. It simply resolves itself into the question as to which of the two vertical pipes of the loop can fill the horizontal D first when a vacuum occurs, and it is found that steam in the riser, although carrying water, is much quicker than the solid column of water in the drop-leg. Of course, once the water is in D it trickles down the drop-leg to the boiler.

It is considered that D should be of reasonably limited length, or should it be very long a part had best be covered. It is only needed to condense just sufficient steam to give the lifting effect required in the riser. It is also considered desirable to put the reducing fitting of the drop-leg on the horizontal side of the elbow so that a certain amount of water is trapped along the bottom of D; this is done with the

* The pressure or weight of water in pipes is 1 lb. per sq. in. for every 2 ft. 4 in. in height.

idea of accelerating condensation of the arriving steam, but it is not really necessary. This is not shown in Fig. 130, only a reducing elbow being used so that D drains quite empty.

The various valves shown are provided to start the loop working thus. When starting, open valve F then turn on steam by valve G and keep F open until live steam blows through. Now close F, open H, and blow through in the same manner, then close H. The loop is now clear of air and water, and contains steam only. By now opening J the water will rise up the drop-leg to its normal height, and the loop should work perfectly as long as there is steam to work it. (F. DYE.)

* * *

STEREOTYPING.

(*See also* ALLOYS.)

THE process of stereotyping is a moderately simple and cheap means by which a frame or "forme" of type, after it has been set up by the compositor, can be exactly reproduced in the form of metal plates. Printing is done from these plates, which plates, when done with, can be melted down for use again.

This process serves at least two good and economic purposes in printing. One is that so soon as the plates are made the type is released for further use, while the plates may be kept as long as required for re-printing, for instance, successive editions of a book, trade-publication, or the like. The second purpose is that, as the plates do not cost as much as type, an economy is effected when printing large editions, as of newspapers, with which a set of type might be badly worn in printing one edition. It may be added that most newspaper machines now carry the type on a cylinder, which would be scarcely possible if plates were not available.

There are two methods of producing stereotype plates, known respectively as the Plaster and the Paper processes. Both are here described, but for large trade purposes, with a few exceptions, the Paper process is almost exclusively used.

Paper Process.—The essential principles of the paper-mould method are as follows: On a pad of soft, pliable paper, built up of several thicknesses of soft paper cemented together by paste, a hard impression from a page of type is taken, which forms a mould producing a face almost equal to the type, etc., moulded. The soft pad is known to the workman as "flong" (a corruption of *flan*, a thin farinaceous cake sold in Paris.) It is laid on a warm and slightly oiled page of type, and the back is beaten with a stiff brush until the soft pasteboard has taken a perfect impression of the face of the type. On the back is now laid a piece of blanket, the whole is pinched in a screw press, the press having been previously warmed. The drying of the mould may, under such circumstances, take from a few minutes to half an hour, according to the temperature and the frequency with which the blanket and other packing is changed. Being clamped between slabs of warm iron, metal is poured in, and a cast is obtained, little if at all inferior to the original type in sharpness. These are the essential features of the paper-mould process, the most important of all stereotyping processes.

The following details are reprinted by permission from the Cantor Lectures delivered by Thomas Bolas, F.C.S., F.I.C., before the Royal Society of Arts.

Working Details of the Paper-Mould Process.—The page of type, or "forme," which is to be moulded, instead of being locked up in the chase surrounded with the ordinary wooden furniture, has a type-high border about ⅜ in. wide around it; but the face of this type-high border does not come quite close up to the type, there being a space of ⅛ in. between them. This type-high border is ordinarily obtained by surrounding the forme with strips of type-metal called "clumps," or "stereo-clumps," these clumps being type high, and about ½ in. wide; but a bevel on the edge placed next to the type reduces the face-width to about ⅜ in., and gives the clear space of about ⅛ in. or so between the face of the clump and the type. The object of the clumps is to form a level bed for the strips of metal—commonly called "gauges"—which determine the thickness of the plate. The space between the type and the face of the clump leaves room for the saw-cut if the plate is to be trimmed close, or for the bevel if the plate is to be trimmed for mounting with catches on a metal block.

Now the forme should be planed level, not too tightly locked up, and its face must be slightly but completely oiled, this being done by rubbing it with a flat brush, not too heavily charged with oil, the brush being about as stiff as an ordinary hat brush. The traditions of the trade ordain that the oil should be the finest olive oil; but, as a matter of fact, neither olive oil nor cotton-seed oil, which is now commonly sold as olive oil, is the most suitable, as these oils—and more especially the latter—are saponified very readily by any trace of alkali which may remain on the forme. A much more suitable oil is the very thin mineral lubricating oil which is sold retail at about 1*s.* 6*d.* a gal. Generally speaking, the forme is slightly warm when oiled; if it is cold and damp the oiling is almost certain to be unsatisfactory, and the mould may adhere to the type.

Materials for Flong.—We now come to a very important matter: the flong and the materials used in its preparation.

Paste and Glue.—First, let us take the paste used to cement the various layers of paper together, and as to this matter one finds in the usual instructions merely a confusing crowd of recipes without the smallest indication as to choice between them, and some of these recipes order the use of materials, the special service of which it is very difficult to conjecture.

As an adhesive, ordinary gum (arabic or acacia gum) is undesirable; it penetrates the substance of the paper, tends to make it unmanageably hard and brittle when dry, and, weight for weight, it gives less adhesion between sheet and sheet than is the case with starch or flour paste. Gum is specially bad in relation to the fine tissue which forms the face of the flong, as in penetrating this it not only tends to adhesion with the type, but, where the gum has penetrated, the face of the cast obtained will have a rougher texture than elsewhere. In addition, gum is expensive, and, what is perhaps worse, very variable in quality.

Starch paste is a very good adhesive, as its water principally penetrates the sheets, leaving the starch where most wanted, and that sponginess, which is a characteristic of good and useful flong, is retained.

Good as simple starch paste is, a paste made from a moderately glutinous flour, such as wheat flour, is better, as the gluten gives the paste greater consistency and adhesiveness without other disadvantages. Moreover, wheat flour paste is easier to prepare and to manipulate than starch paste, and, if measured by adhesive power, is very much cheaper. Besides, it penetrates the paper even less than starch paste. Altogether, the advantage rests with wheat flour paste as the main adhesive.

Glue (the term includes gelatines and sizes) by itself is not a very suitable or desirable adhesive to use, as it is subject to the same disadvantage as gum arabic as regards penetration of the paper, yet in a lesser degree; but, when used in conjunction with sufficient flour paste, the penetrating quality is eliminated, and owing to the setting of the glue the flong acquires increased sponginess, and also the valuable quality of being more rapidly compressed by the face of the type when the metal is warm, as the glue melts and consolidates the compressed parts. In addition, by the use of glue along with flour paste the flong becomes capable of holding rather more water without becoming flabby, and where the flong is not compressed, it dries more spongy than would otherwise be the case. There is advantage in using glue with the paste, whether the type is to be moulded cold or warm, but very especial advantage in the latter case. The sort of glue most suitable is the soft and degenerate glue sold retail in the oilshops at 4*d.* per lb., high-priced hard glues and fine gelatines being very much less suitable. Instead of using glue, it saves time to purchase size, but care should be taken to use the low-priced size, sold as common size (14 lb. for about 1*s.* in London oilshops), and not the harder and finer size known as "patent size."

We may then dismiss all adhesives but flour paste and glue; the former can be used by itself, but glue by itself is not very satisfactory. Together they give the best results, for reasons already stated.

It is desirable to mix some mineral matter with the paste, and for this use we find, among other additions, the following recommended: Whiting, litharge, white lead, kaolin, other clays, Paris white, zinc white, barytes white.

The use of the mineral matter is twofold. It makes the compressed parts of the mould more hard and stony than they would otherwise be, and less subject to blister or scale during drying or casting, and it makes the uncompressed parts of the flong more spongy and uniform in texture. At the same time it makes the whole mould more resistant to heat.

Of the above, the only very definitely objectionable substances are litharge and white lead, as, owing to the moisture and heat the lead poison is specially liable to be absorbed into the system of the workmen; and of the rest, whiting seems the best, its softness of texture, fineness, and the ease with which it is compressed, enabling it well to fulfil the double function as stated above. In short, not one of the above is superior to whiting, which, moreover, is cheap, and easy to get.

We now come to the preparation of the paste. Into an iron pan put 6 lb. whiting and 20 lb. (2 gal.) water. If the whiting is allowed remain in the water for one to two hours it will be found that the lumps have completely broken down, and the mixing will be easy. If, on the other hand, you try to mix whiting which has only just been put in the water, it works into clots and becomes unmanageable. The hands form the most convenient tools for mixing the whiting and water, as also for working in the next addition, 4½ lb. wheat flour.

This being thoroughly incorporated, the pan is set for the mixture to boil, it being constantly stirred with a wooden stirrer, having a T-shaped head which can be kept in motion close to the bottom of the pan, and so eliminate all chance of burning. As soon as the mixture boils add 14 lb. soft size, or 3½ lb. common glue, 10½ lb. (1 gal. and nearly ½ pint) water. The glue to be soaked in the water till quite soft.

In order to give the paste such qualities as shall ensure the mass keeping good for years, 4 oz. crystallised phenol (carbolic acid) are now stirred in, and all that remains to be done is to work the mixture through a sieve having about 20 meshes to the linear inch, or it may be strained through a piece of net.

Paper.—Three sorts of paper are used in making the flong. First, a fine hard tissue paper for the face; secondly, blotting paper to form the porous body; thirdly, stout and tough brown paper for the back, to give strength and to support the blows of the beating-brush. It is of very great importance that the tissue paper which forms the face of the flong should be strong and fine in fibre, uniform in texture, and free from holes, all qualities which add to the expense of a paper, and any expenditure which secures the above is well bestowed, economy on this score being bad policy. A tissue which becomes pappy and soft when in contact with the paste, or which allows its exudation through holes, may cause adhesion between the forme and the mould, with the attendant delays and disadvantages. The tissue papers sold for pottery transfers are generally very suitable for stereotyping, and some makers supply a special kind.

As regards the blotting paper, the cheaper sorts answer as well as the more expensive, and I do not think the lowest priced papers contain irregularities or lumps so pronounced as to be disadvantageous.

The brown paper for the back of the flong should be made of tough, strong fibre, free from knots and lumps; moreover, it should be soft, and not heavily rolled. Such a paper is expensive, costing about 4*d.* per lb.; but, as in the case of tissue, it is poor economy to use a backing paper of unsuitable character.

To prepare some flong, the materials will be :—

	Approximate weight, gr.
Brown paper (1 sq. ft.) . .	200
Blotting paper, 3 thicknesses (3 sq. ft.)	355
Tissue paper (1 sq. ft.) . . .	25
	580

Preparing Flong.—The brown paper is laid flat and pasted uniformly by means of a rather soft, flat brush, the paste being, by preference, slightly warm, on account of the glue it contains, although, with the above-mentioned proportions, it is possible (though undesirable) to work it cold. A sheet of blotting paper is now laid on, and the pasting is repeated over each layer of paper, but in the case of the last pasting, which holds down the tissue paper, only a small quantity should be applied, and that as uniformly as practicable. A convenient way of laying down the tissue paper is to roll it on a wooden cylinder, and then to roll it off this on to the pasted surface; and all through the operation great care should be taken that no paste comes in contact with the outside face of the tissue; generally speaking, the wooden roller requires wiping after each use. Close contact of the several constituent sheets of the flong is best ensured by laying a clean paper over it after each addition, and rubbing it down with the hand, or with a cloth folded so as to form a pad. Hard rolling should be avoided, as it tends to lessen that sponginess which is so desirable a quality.

If the paste has been applied in about the right quantity, the sq. ft. of flong, the paper of which weighed about 580 gr., will, when wet and fresh, weigh about 1400 gr., about 820 gr. of this being paste ; in this state it is too wet and too soft for convenient use, but if exposed to the air until something like 300 gr. of water have evaporated—that is to say, until the sq. ft. weighs about 1100 gr.—its consistency will be right for working. These weights are given principally in order that persons working from directions may be able to prepare a sample which shall have a convenient consistency, after which the remembrance of this sample should be a sufficient guide.

It is desirable to prepare the flong in the first instance with excess of moisture, and to allow this to evaporate spontaneously, as during this process of evaporation the paper swells and takes a plasticity and sponginess which is difficult to obtain in any other way. Moreover, the manipulation of making the flong is easier and more satisfactory when a soft paste, containing a full proportion of water, is used. If, however, one has occasion to prepare a piece of flong for immediate use, the best way is to employ as little paste as practicable. Quite apart from the question of the amount of moisture present, it is undesirable to make use of freshly prepared flong, as it is never so homogeneous as that which has been kept for some days. It may be stored in a varnished tin tray of the right size, a stout plate of zinc being laid on the top. Generally speaking, it is best to lay the sheets of flong face to face, as the backs are likely to have been soiled with the paste, and paste should be kept from the face. Flong prepared with the above-mentioned paste will keep any length of time without decomposition or mildewing, but it may become partially or completely dry. This may be remedied by one or more dippings in water, with a full allowance of time for its absorption. When flong has completely dried it is rather a trouble to get it once more into good working condition, the best way being to dip it in cold water, pile it in the storing tray, and keep this latter in a warm place, repeating the operations, if necessary.

Dry flong is an article of commerce, but it is more trouble to get it into good working condition than it is to start with the plain sheets of paper. It is often recommended to use two thicknesses of tissue paper on the face of the flong, and to interpose tissue between the several sheets of blotting-paper, but these courses are open to objection, and have no balancing advantage. Two thicknesses of tissue on the face, with paste between, offer no greater security against paste reaching the type than does one thickness of tissue, and, moreover, for ease and rapidity of application, it is desirable to make the paste as fluid as practicable, and also to so work as not to involve the extra care and labour consumed in applying very thin layers of paste, and it is obvious that the larger the proportion of thin paper entering into the composition of the flong, so much thinner must be the layers of paste in order to obtain flong containing the same proportions of paste and paper. It takes much longer to spread a very thin layer than a moderately thick layer of paste.

Preparing the Formes.—Ease and quickness in working are generally on the side of moulding small formes rather than large, so that, when work is sent in assemblages of many pages, it is often desirable to re-impose, so as to bring down the dimensions to demy folio, or thereabout ; but when large pages of close matter, such as newspaper pages, are concerned, the stereotyper has no option but to mould the formes as received. When several pages are imposed together for moulding, it is sufficient to allow a pica ($\frac{1}{8}$ in.) between them, unless the edges are to be bevelled, in which case twice as much space will be required to allow for the saw cut and two bevels. The type-high clumps, as before stated, surround the whole.

Sometimes the stereotyper will have to clean the forme himself, and in this case it should be scrubbed over with a solution of the cheapest quality of caustic soda in water (1 part soda to about 8 water), well rinsed and dried.

The forme, clean, dry, oiled and warm, is laid on a planed slab of iron, or "beating surface," heated from underneath, the heating being by gas or steam. The beating surface may be, and often is, an extension of the bed of the drying press (Fig. 131). The hand is now lightly passed over the face to detect any letter which may stand high, and the "planer" is brought into use if necessary. All is now ready for the moulding. Take a piece of the flong, dust its surface over with powdered French chalk, taking care to wipe off all excess, then lay it face downwards on the forme, and now comes the operation of beating.

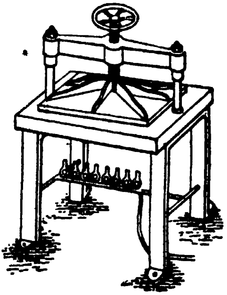

FIG. 131.

Beating.—The brush used for beating may vary in shape or weight, according to the habit of the workman, but the bristles must be good and closely packed, and the operation of beating is so similar to that of driving in a nail, that any person who is able to strike his nail every time in such a way that it shall be sent forward and without any tendency sideways, will probably make a satisfactory mould the first time; while one in whose hand the hammer sways round uncertainly and uncontrolledly, hitting the nail at all sorts of angles, and perhaps even bending it, will not be very successful in making a paper mould from the type. In such a case it is perhaps better to educate the mind to the conditions necessary for successful hammering, by watching and painstakingly learning to drive drapers' pins up to the head in deal, than to waste flong and spoil type.

The face of the brush must fall flat on the back of the flong, very little side-driving being sufficient to shift the flong, and spoil the sharpness of the mould ; and a good plan is to first beat a line right across the page, and then to extend this first towards one end of of the page and then toward the other. A damp cloth is sometimes laid over the flong in beating, but if the brown paper is tough and nervy the cloth is not needed, and much time is saved by not using it—far more than is equivalent to the difference in price between good and bad paper. Moreover, when the cloth is used, it becomes difficult to give such local treatment as is necessary on parts where words or rules stand almost by themselves, or where there may be a mass of small type closely set, to say nothing of the special treatment required where engravings are included in the forme. As a rough guide to the extent to which the beating is to be continued, it may be stated that with flong of the right degree of softness, the divisions between the words set in long primer or brevier should show distinctly on the back of the flong. If the flong is very soft, the beating must not be continued until these divisions are so distinct as with normal flong, and if the flong is very hard one will only obtain sufficient relief by making the divisions show very clearly.

The progress of the beating may always be seen by steadying the mould with one hand and turning back one corner, and the flong should always be so soft that this can be done without straining or stretching the part turned over. Where there are extensive whites in the forme, the mould will be arched downwards and some support is needed in such places, or the arched parts would crush down by the weight of metal in the casting-box, and much metal would have to be cut away from the plate. The usual way is to paste the back of the flong, and to lay in the deep parts a few pieces of paste-board or of old mould, after which a second sheet of brown paper is pasted and laid over all. A very gentle beating is now given to the mould, care being taken not to beat this last paper down into the hollows, as the main use of this sheet is to string or tie the domes and hollows formed in the main part of the flong.

Another way—more employed in newspaper offices—is to fill in the hollows with whiting, or dry plaster of Paris; the pasted sheet of brown paper being laid over as before.

The impression is now sharpened up by planing. The printer's planer—which is a slab of hard wood—is placed on the mould and struck several times with a mallet. This should be repeated several times, moving the planer between-times, and care must be taken not to shift or strain the mould sideways. Two or three thicknesses of blanket, or still better enough blotting paper to make up about ½ in. thick, being placed over the mould, the forme and mould are pinched up in the drying press.

A few words more about the beating brush. If the face is not level, or should become unlevel by use, it may be burned flat by contact with a plate of iron heated to a dull redness, and by the same means the edge and corners farthest from the handle may be very slightly sloped off, thus making it more easy to give local treatment to any special part of the mould. Workmen who have skill and confidence in the use of the brush may strike tolerably hard, and they often find it a convenience to load the brush by fastening a plate of lead to the back. A rolling machine, or a vertical press, is occasionally used in making the mould, but the press and rolling machine are of little use except in the case of tolerably solid and uniform formes, such as the pages of a newspaper. The rolling machine for moulding consists merely of a moving bed with an adjustable cylinder over it, bed and cylinder being geared together. The machine, however, is seldom used without the brush being used as an adjunct. Sometimes the press or machine is used to set the flong firmly in position on the type, the brush being used for finishing; and sometimes the brush is used first, and the machine is employed to sharpen up the impression, to do what the planer does in the process of making a mould by hand.

Drying the Mould.—A sufficient drying of the mould may be effected in as short a time as three to four minutes, in which case the heat is urged almost to the softening point of the type, or the heat may be more moderate, so that the drying takes as much as ½ hour. It may, however, be taken that in the case of ordinary commercial stereotyping some water is invariably left in the mould; many hours' baking at a temperature of 200° C. being necessary for the removal of the last traces of moisture. So that, when the best possible results are required, it is desirable to considerably extend the time allowed for drying.

In ordinary cases—the work not being subject to the extreme need of haste which exist in the case of newspaper stereotyping—the forme will remain in the drying press for ten to fifteen minutes, during which time the blanket (or covering of blotting paper, as the case may be) may have been changed two or three times; or if this is not done, the press should be undone, and the covering turned over to allow the more ready escape of moisture. All this time the bed of the press may be conveniently heated to a temperature of 100°-130° C., the former being about the degree of heat obtained if the bed forms the top of the steam-chest fed with waste or "exhaust" steam; but if "live" steam of about 30 lb. pressure is used, the temperature will be something like 130° C.

To return to the forme and mould. The mould leaves the forme at once. When any adhesion occurs, something is wrong with the work, e.g., tissue paper not impervious; excess of paste under tissue paper, thus breaking up tissue; tissue broken in beating, from too hard blows or extreme softness of flong; mould too deep, so as to fit over the shanks of the types, or even penetrating between them; paste on face of the flong, from careless making or piling; imperfect oiling of forme, or unsuitable oil; alkali or other foreign matter on type.

But a slight tendency to adhere can generally be combated by repeatedly lifting the edges of the mould, as far as is possible without bending or straining the mould, and then letting it spring back; at the same time slightly loosening the quoins and beating the back of the mould with the brush. (Fig. 132). In the case of persistent sticking, the only alternative is to heat the forme once more and repeatedly moisten the back of the mould with water. In this case the mould will be spoiled.

FIG. 132.

The mould, as it comes off the forme, is dry to the touch, but ordinarily not dry enough to give a good cast, and, before drying it further, it is convenient to trim the edges to the outsides of the gutters left by the clumps; and to paste on to one end a flap of brown paper long enough to project 2 in. or so out of the casting-box, and, at the same time, to allow a head of metal of not less than 6 in. For this purpose, a more adhesive paste is required than that used for making the flong. Stiff rye flour paste is best.

The mould may now be laid on a hot surface to further dry, or, better still, it may be baked in a steam or gas oven, heated to about the same temperature as the moulding press; but in any case it should be kept flat by placing over it a piece of heavy but small-meshed wire net, and if necessary a weight is put upon this. A suitable wire net is made with iron wire of No. 16 I.W.G. (0·064 in. diameter), and six meshes to the linear inch, and can be had from firms that furnish millers' plant. The ordinary wire gauze or net sold at the hardware shops, having six meshes to the inch, is made of much thinner wire, and is not much used for the present purpose, as it has not sufficient rigidity to keep its shape as a slab or plate. The wire net should be in contact with the tissue paper side or face of the mould, as slight indentation on this side will do no harm, whereas any indentation on the back of the mould will show on the face of the cast; and when several moulds are piled in the oven for baking, they should be laid back to back and face to face, with a piece of sheet metal (say stout tinplate) between the backs, and one of the wire-net sheets between the faces.

Casting.—The baking, or second drying, being at an end, we come to the casting, and before this is done it is a very common practice to brush some finely powdered French chalk into the mould, and then to dust out the excess by turning the mould face downwards, and gently beating the back with a flat slice of cane. This is quite unnecessary if the mould is very dry; but by the use of French chalk the effect of any trace of moisture remaining in the mould is minimised, and, moreover, the cast separates from the mould more easily—a matter of some importance when it is wished to make several casts in the same mould.

All is now ready for laying the mould in the casting-box, the casting-box having been warmed by a gas jet underneath, or by casting a few blanks in it. The mould is laid face upwards, on the horizontal slab of the casting-box (Fig. 133), the brown paper flap hanging a little over the lip of the box. The pica-high gauges are laid along the gutters formed by the clumps, the top leaf of the box is closed down and clamped by the screw, and the casting-box is swung on its axis, so as to bring the lips to the top.

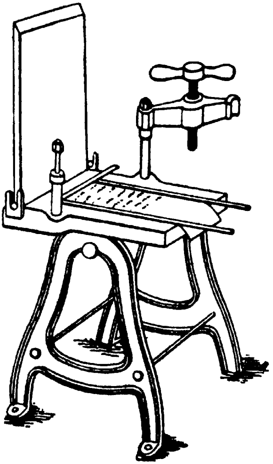

FIG 133.

When stock sizes have to be stereotyped, it is convenient to use set gauges, like Figs. 135 or 136, but in other cases it is usual to employ adjustable gauges, such as Fig. 134.

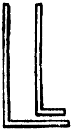

FIG. 134.

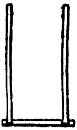

FIG. 135.

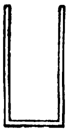

FIG. 136.

When the mould is charged with type-metal, it is necessary, in order to obtain a good cast, that the whole of the metal inside should remain fluid until the mould is completely filled with metal, as if any part solidifies before the mould is full, the cast is sure to show curved streaks where the cast has solidified, and the fresh metal has not run up so closely as to make a sound cast. This is most noticeable at the back of the cast, where the casting-box exercises the most sudden cooling action on the metal, and the object of heating the casting-box is to diminish the tendency to this sort of thing. Heating the casting-box is generally insufficient in itself, when the cast is large, unless the heat is raised to nearly the melting point of the metal —an obviously inconvenient course. It is very much more convenient and satisfactory to warm the box only slightly (say to about 100° C.), and to cover the face with a non-conducting coating, which may be extremely thin; in fact, it is sufficient to sponge the iron plate over with a very thin wash of jewellers' rouge (finely divided ferric oxide, or, practically, much the same thing as finely divided iron rust) and water, a film of the oxide so thin as to be scarcely noticeable serving to retard the solidification of the metal during the short time required to fill the mould. Although a thin wash of jewellers' rouge is the best coating material to employ when very delicate castings of type metal are to be made in metal moulds (as for example, in casting the thinnest "leads"), a thicker and coarser mixture, made by stirring ½ lb. red ochre into ½ pint water, is often used, this being applied with a brush. London stereotypers, however, more usually lay a sheet of thin cardboard over the back plate, or a sheet of thin paper will be quite as effectual in preventing the chilling of the metal; but stereotypers generally prefer the card, as lasting longer and being easier to handle. The card, however, is liable to blister, and so cause inequalities in the thickness of the plates. In the absence of a metal casting-box, excellent work may be done by using two slabs of dry wood, held together by screw clamps.

All is now ready for the casting of the stereotype plate. To ascertian whether the temperature of the metal is about right, a strip of card or of old mould is immersed in it for a few seconds. If the card becomes of a medium brown, the heat is right (about 320°–330° C.), if it chars and blackens, the temperature is too high; should it merely become yellowish or light brown, more heat must be applied. When the metal is too hot, it can be rapidly brought down by stirring in some cold metal. It is important that, when poured, the surface of the metal should be clean and free from scum or oxide, as this might lodge in the cavities of the mould and render the cast unsound; and the most convenient way of cleaning the surface is to throw into the pot some powdered resin, which melts and so far agglomerates the oxide that it can readily be removed by skimming with a perforated iron spoon. Sufficient metal is now taken out of the pot by an iron ladle —one with a flat pouring-side (Fig. 137) is often used—and the metal is poured steadily, but not so quickly as to cause splashing, into the mould. Under ordinary circumstances, it makes but little difference whether the stream is poured against the back plate of the casting-box or against the face of the mould, although the former is the most usual course, and some persons make a point of drawing the ladle along the lips of the mould during the operation of casting.

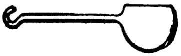

FIG. 137.

The metal used for stereotyping is much the same as ordinary type metal, only, as a rule, the stereotyper is content with an alloy tending too much towards softness, while of late years type founders have been moving in the direction of harder and harder metal. An alloy well suited for ordinary work contains 20 per cent. of antimony, the remainder being lead; or lead 4 parts, antimony 1 part. For preparing this alloy a very safe lead to use is the soft lead which has formed the linings of tea-chests, or if commercial pig lead is used, a soft sample should be selected, and this may be sufficiently judged of by scratching the surface with the finger nail. Hard pigs often contain traces of zinc; this metal, which is especially bad in stereotyping alloys, being used in some of the desilverising processes, and the last traces are not always removed. When, however, the hardness of the pig-lead is known to be due to antimony, copper, or tin, it may be used quite safely; in fact, hard lead then becomes more desirable than soft lead. The lead and antimony being put together into the iron melting pot, sufficient heat is applied to melt the former, when the antimony gradually dissolves in the melted lead, forming an alloy which fuses at about 300° C. Lead melts at something like 330° C., while antimony fuses at 450° C., or a low red heat; the stereotype metal following the general rule that alloys melt at considerably lower temperatures than the mean melting-points of their constituents. Sometimes stereotypers reduce the proportion of antimony so that the alloy only contains 10 per cent. of the metal, but in this case the alloy is noticeably soft, and wears badly in printing. A very superior stereotype metal, which is not only harder but more fusible than the above mentioned, can be made by melting together 3 parts lead, 1 of antimony, and 1 of tin. Old mixed type generally makes an excellent stereotype metal, and will often bear the addition of nearly half its weight of lead. Type metals, like so many alloys, are harder when the cooling has been very rapid than when it has been comparatively slow.

The most positively objectionable impurity likely to find its way into the stereotyping metal is zinc, this metal making the alloy flow badly, and the face of the cast rough and patchy, doubtless by its tendency to separate from the other metals. It is, therefore, important to keep watch against its introduction into the stereotype foundry, and in melting up old type or scraps, any portions which remain unmelted and float on the surface after the bulk is fused should be skimmed off, as these are likely to contain the lighter and less fusible zinc. The larger the proportion of lead in the stereotype metal, so much greater is the evil effect of the zinc. Zinc in lead or in type metal may be removed by calcining at a low red heat, the zinc oxidising with the first portions of the lead; but the same treatment also removes the antimony, or at any rate a considerable proportion of it. The tendency of antimony to oxidise is so much greater than that of the lead, that stereotype metal used many times becomes softer from the loss of antimony. A little arsenic—say 1-2 per cent.—increases the fluidity and hardness of a stereotyping metal.

Trimming the Plate.—Now take the stereotyped plate out of the box and the usual thing is to trim it, or cut it up into pages with a circular saw, and as the cuttings are carried round by the saw, and thrown upwards and forwards by the ascending side, it is usual to fix a screen (as shown in Fig. 138), to prevent them going into the eyes of the operator. The screen is ordinarily made of sheet metal, but sometimes a neatly fitted and curved glass plate is used. Generally speaking, however, I have preferred to use a leaf of the transparent flexible celluloid, which can now be readily obtained as thin as a card, and as transparent as glass.

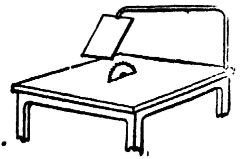
FIG. 138.

Instead of a circular saw, the tool known as a zinc hook (Fig. 139) may be used for dividing the plate. A metal straight-edge is used as a guide, and the cutting edge of the zinc hook is drawn along it a sufficient number of times to plough a groove half through the plate, when it becomes easy to break it.

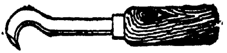
FIG. 139

For trimming the edges, a hand plane is ordinarily used in conjunction with a shooting board, the ordinary wooden shooting board and jack-plane of the joiner answering the purpose very well. Fig. 140 represents an iron shooting board and iron plane specially made for stereotypers' use, a second plane being provided for bevelling. When the trimming planes are driven by power, the arrangement is generally substantially similar, the plane moving to and fro on a guide, while the plate to be trimmed is fed up against it, although sometimes a revolving cutter is used instead of a plane.

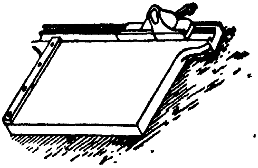
FIG. 140.

Thin stereotypes, cast pica-high for mounting on blocks, ought not to require planing at the back provided that reasonable attention is devoted to matters which influence their thickness and truth, such as the flatness of the slabs of the casting-box, the accuracy and right placing of the gauges, the keeping of the mould flat while drying, and the proper condition of the cardboard covering the back slab of the casting-box. It is easy to cast plates so true as to require no planing, indeed, so true that the arrangement ordinarily used for planing, or rather scraping, the backs of thin stereotypes would make them worse, not better. This arrangement is a kind of drawbench in which the plate is slowly forced under a stout knife placed almost vertically, and one form of it is represented by Fig. 141.

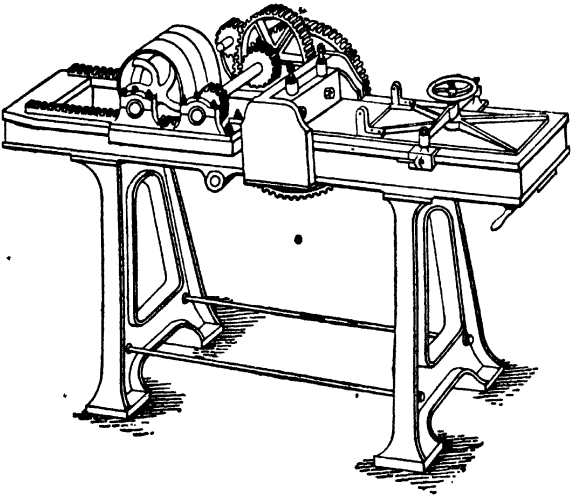

FIG. 141.

The travelling part is one with the two racks, while the double gearing and the arrangement for reversing by shifting the strap from the middle pulley—which is idle—to the right or left, according as one wants backward or forward motion, will be obvious to anyone who has given attention to machinery. The slow heavy cut, with a cutter at right angles to the plate, is essentially wrong, and tends to drag the plate out of shape, and, unless care is taken, will sometimes lift it from the bed of the machine. A machine tool for cutting stereotype metal will not work efficiently at a much less speed than 12 ft. per second between it and the metal. In ordinary cases, the cut is clean and easy with such a speed, and an angle of 60° on the approaching side, and 15° is a good angle for cutting edge, leaving an angle of relief of 15°. When a cutting tool rapidly removes small shavings of stereotype metal—as in the case of a circular saw or rotary cutter—there is a tendency for the clean particles of metal to weld together, and also for some of them to weld upon the clean surface of the work, thus making it rough, but a minute film of thin mineral lubricating oil prevents the tendency to welding, and it is generally sufficient to allow a brush charged with the oil to very lightly play against the cutter or the work, according to circumstances. The free use of oil on stereotypes is objectionable for obvious reasons. For heavy work, water containing a little soap is more efficient, but it must be used freely. The above remarks as to the relation of stereotype metal to cutting tools apply more especially to the ordinary and rather soft alloys. But a planing machine with a revolving cutter like that used for thicknessing floor boards might always be used for the backs of stereotypes when planing is required.

Mounting.—In most cases — at any rate for jobbing work—the stereotype plates are brought up to type height by being nailed or screwed down on mahogany boards, these being, roughly speaking, ¾ in. high; and, from the printer's point of view, it is very desirable that the thickness of the whole should exactly equal the height of the type, a matter which may very well be gauged by a sort of bridge (Fig. 142), under which the mounted stereotype can be just passed if it is the right height. Wood blocks expand when exposed to damp, and contract when they dry, and consequently they vary from time to time; so printers, when using wood-mounted stereotypes, would save time by passing them one at a time, and face downwards, under such a bridge set to type height. The low places can then be readily brought up with paper patches in far less time than when made up in the chase. As a matter of fact, stereotypers very seldom send out the blocks too high, as the printer finds it much easier to pack up than to plane off.

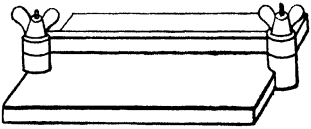

FIG. 142.

Printing from stereotype plates becomes much more easy and certain if, instead of being mounted upon material which, like wood, varies in thickness with difference in the degree of dryness, the plates are either cast type-high in the first instance, or are mounted upon some firm foundation not subject to considerable variations of thickness.

Casting the plates type-high is a common practice for ephemeral work, as in that case the plates can be melted as soon as done with; but it is the usual practice not to cast the plate quite solid, a number of hollow spaces at the bottom, generally arched or domed, serving to lighten the plate. Any person with elementary notions of handicraft can devise for himself ready means of making cores for placing in the casting-box so as to produce the required cavities, and several ingenious forms of adjustable core are now made, among which may be specially mentioned that in which a set of core-bars of graduated sizes enables one to readily cast type-high blocks to any required width. For very small blocks it is more convenient to cast solid, and if reasonable care is taken the blocks may be cast so accurately to type-height that planing at the back becomes quite unnecessary, and the sides may readily be squared up with the hand plane, or sometimes it is more convenient to cast small metal mounting-blocks, and to solder the thin stereotypes upon these.

Metal mounting-blocks, upon which bevel-edged stereotype plates are held by catches placed round the edges, are on the market in various forms, much cleverness being sometimes noticeable in the devices for enabling the printer to build up any required size of mounting-block out of stock sizes.

Finishing.—It very often happens that the stereotype requires some work done upon its face, such as cutting away the parts corresponding to large white surfaces, raising low parts or "sinks," or soldering in letters or electrotypes. For chipping away extended whites a very convenient tool is the carpenters' gouge, driven by a rather light mallet, an assortment of four or five gouges, the narrowest about $\frac{3}{16}$-in. across, being ample. When chipping away the metal with gouge and mallet, it is desirable to place the stereotype on a planed iron surface, provided with a transverse bar against which it can rest, the iron shooting board (Fig. 140) being convenient for this purpose. For working in narrow places, and close up to the type face, a "firmer" chisel of suitable width may be used, or a scraper shaped like Fig. 143, and one angle of the scraper may advantageously be ground on the edge of the grindstone, so as to shape it into a chisel-like tongue about $\frac{1}{16}$-in. wide, or a special tool, like Fig. 144 may be used for scraping between the lines. Sometimes a routing-out machine is used, in which a conical dome-shaped revolving cutter, provided with universal movements, is brought down on the plate; but, in ordinary cases, there is little or no saving of time by the use of such a machine. When there is a "sink" on the face of the stereotype—this being generally a result of an arching of the mould*—it may be brought up by laying the plate face down on a planed iron surface (a sheet of paper being interposed if this is thought necessary), and hammering on the back with a broad and round-faced hammer, such as that used by shoemakers for beating out leather; a little paper packing being then pasted on the back to support the hollow. In beating down the "sink," care must be taken to strike in the middle of the place rather than at the edges, and to strike the fewest blows that will do the work, otherwise the plate may be distorted so much as to render it useless. In the case of the thick curved stereotypes used for newspaper work on rotary machines, the machine-minder will often bring up a low line* by driving a chisel obliquely into the metal above it and below it.

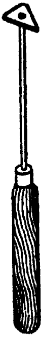

FIG. 143.

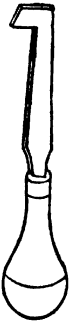

FIG 144.

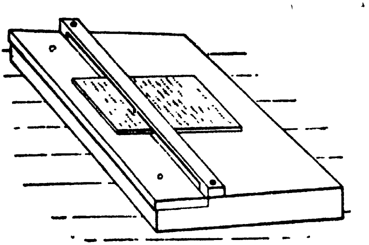

FIG. 145.

Repairing Plates.—Cutting out a false letter and soldering in a type requires some care and watchfulness, but it is very easily done. The stereotype is clamped face upwards on the punching-out slab (Fig. 145), and with the line containing the false letter immediately in front of the bridge. The adjustable part of the bed, shown at the left of the diagram, being now set so as to leave a gap exactly under the line, the chisel (Fig. 146) is used to make an indentation round the letter, at any rate on those sides where access can be had, the chisel being placed with the unbevelled side next the letter to be removed, and being held vertically. A punch like one of those shown in Fig. 147, and of the right size for the letter to be removed, is now held firmly atop of the letter, and is driven through the plate by a hammer. Any metal driven beyond the plane of the back may now be cut off with a sharp chisel; and if any indentation of the face round about the hole is visible, it can be dealt with as recommended in the case of a "sink." The hole is now trimmed by means of a rectangular file,* to the bare size of the type to be inserted, and the type, after having been scraped clean on the sides, is inserted from the back. The face of the letter having been adjusted to its exact position and level, the stereotype is laid face downward on the punching-out slab, no paper being interposed between them. A little powdered resin is dusted on, and, with a rather fine-pointed soldering bit, a trace of solder is applied at two opposite points of the join. The shank of the type is then nipped or broken off, and the place is filed or scraped level. Sometimes a skilled workman will put a patch of solder over a false letter, and out of this engrave the required character, but such a method of working is more usually adopted when a dot or the tail of a letter is broken off and must be replaced.

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* May arise from a scrap of metal or other foreign body under the flong, penetration of liquid metal through a hole in the flong, or the joint of the paper flap, from distortions of the mould during drying, or by careless clamping up in the casting-box.

* The standing lines in newspapers and periodicals are often low to paper.

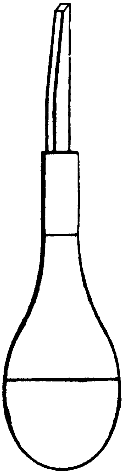

FIG. 146.

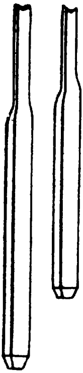

FIG. 147.

The soldering is very easy if a few points are attended to. The copper bit being heated to a heat a little under redness, is rapidly cleaned about the point with a file and quickly dipped into an acid solution of chloride of zinc,* and then rubbed on a stick of soft solder which itself has been moistened with the same solution; it thus becomes well amalgamated with the solder, or is "tinned," to use the expression of the workshop. To keep the soldering bit in a good condition its tip may be rapidly dipped in the acid chloride of zinc solution after each heating, and being then charged with solder it is ready for use on the stereotype plate, and if the part to be soldered is sprinkled over with powdered resin this will be sufficient protection, and the small drop of solder carried up on the tip of the bit will unite and flow readily. The acid chloride of zinc solution should not be applied to the type metal, as it rather corrodes it than protects it.

When much soldering has to be

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* Files of rectangular section down to a square file about $\frac{1}{16}$ in. across can be obtained at watchmakers' material shops of Clerkenwell or Soho.

* Commercial hydrochloric acid saturated with zinc, and when poured off from the excess of metal, is mixed with one quarter its bulk of hydrochloric acid.

done, as, for example, if electrotypes of wood-cuts are to be soldered into stereotype plates, a soldering bit, heated by a small gas blowpipe, is a great convenience and saving of time, and the device represented in Fig. 148 is a specially convenient one for the stereotyper, and the instrument itself can easily be constructed by any all-round mechanic. The tubes leading gas and air respectively (the air being conveniently supplied by a foot bellows) are shown first passing through a wooden handle and thence into the cylindrical head of the apparatus, where is fitted a small Herapath's blowpipe, the flame of which plays upon the small copper bit held, as shown, by two lugs extending from the cylindrical head. A cock is placed on the gas-pipe just over the handle, and where it can be operated by the thumb of the right hand, while the crutch shown on the figure forms a convenient support for the blowpipe when not in use.

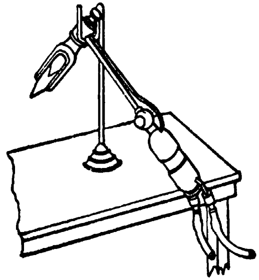

FIG. 148

Although very little care and attention on the part of the workman will enable him to use the ordinary soft solder of the tinman without fear of melting the adjacent parts of the plate, there are cases where it may be desirable to use a more fusible solder, in which case Wood's cadmium solder may be employed. It melts at a temperature considerably under that of ordinary solder, works nearly as easily, and is quite as strong. It is prepared by melting together cadmium 2 parts, tin 4 parts, lead 2 parts.

An alloy of bismuth 2 parts, tin 1 part, and lead 1 part, forms a solder easy to use, moderately strong, and melting below the boiling-point of water. When figures have to be altered several times this solder is convenient to use, as those first soldered in can be readily removed by immersing the plate in boiling water, or heating it till, when touched with a wet finger, one can just feel steam formed, then giving the figure a slight tap to drive it out.

Casting Curved Plates.—In stereotyping for newspaper work, everything is carefully studied to attain speed, especially in the case of the evening papers, and it becomes possible to mould a page and cast a plate in about ten minutes. In such cases, the plates are cast curved, so as to fit the cylinder of the machine used.

Two workmen beat the flong to make the mould; a rolling press being often used to finish the moulding. There is generally very little packing of the whites to be done, so it suffices to sprinkle a little whiting upon the back of the mould, and scrape it into the hollows with a straight-edge, after which the final thickness of brown paper is pasted on, and the forme is run under a hot press to dry, the heat being as great as can be ventured upon without damage to the type. In two to three minutes the mould is removed, finally dried on a hot surface for another similar period, is dusted with French chalk, and is then placed in a curved casting-box (Fig. 149), the metal being poured in at the side of the page, while in the older pattern of curved casting-box it was poured in at the top. The metal is poured from a large three handled ladle, like that used in iron foundries. The trimming of the cast is generally done while it is warm, and by slow-moving tools, as chips rapidly removed from the hot metal are more likely to weld on the freshly-cut surface than is the case with cold metal.

Therefore the ordinary machine for boring the inside of the cast, and in which a single knife is made to revolve slowly and take one heavy cut (Fig. 150), is less unsuitable than might at first sight be supposed. But in this case, if a revolving cutter were used, and were fed with slightly soapy water by a series of conduits in the cutter-bar, it is quite likely some economy of time would be effected. Soap, like oil, soils the surface of the type metal sufficiently to prevent welding.

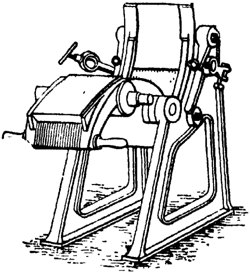
FIG. 149.

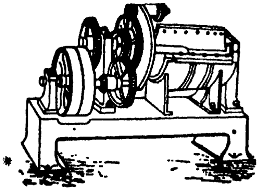
FIG. 150.

A common form of apparatus for trimming and bevelling the edges of curved stereotypes is that shown in Fig. 151, the plate being clamped down on a suitable saddle, and trimmed by adjustable knives, the holders of which are moved backwards and forwards by hand. Another trimming machine is represented by Fig. 152. In this case we have a revolving cutter, and the plate is fixed upon a saddle which traverses and rotates by hand gearing.

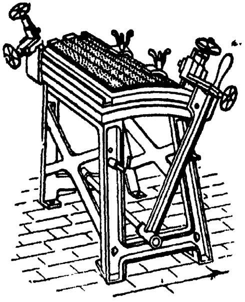
FIG. 151.

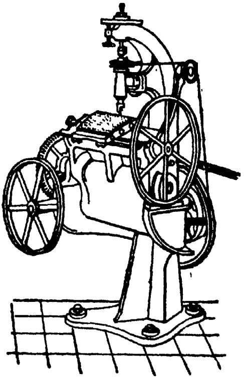
FIG. 152.

Bending Plates.—Occasionally plates intended for printing on rotary machines are cast flat and afterwards bent to the required curve, and there are two methods of doing this. In one case the plate, previously warmed, is forced down into a curved die by a sort of platen formed of stiff leaves of spring steel, but when the same machine is intended to bend to any curve, a bed piece, similarly formed of plates of spring steel, must be laid over the die. In the other case the stereotype is laid between steel plates thin enough to spring, and is rolled several times through a set of three rollers, one of which is adjustable so as to give the required set.

In either case it is necessary to place paper or a blanket between the face of the stereotype and the steel plate, and the results of the bending are seldom quite satisfactory, unless the plate to be bent is fairly solid, as in the case of an ordinary newspaper page, any extended whites interfering with the regularity of the bending. In the case of electrotypes, which are ordinarily backed up with a softer metal, the bending is easier, and electrotypes are often bent that they may be soldered into curved plates for illustrated newspaper work.

Wood Mounts and Heat.—The work of the newspaper stereotyper is very seriously interfered with if any wood-mounted blocks are inserted in the forme he has to mould, the heat passing so much more slowly through wood than through metal as to make it almost a matter of certainty that the mould will be less dry when over such blocks; this being not only calculated to give a rough face to the lines, but also to lead to a distortion of the face of the mould in the second drying. This evil is especially apparent in the case of the zinc process blocks, which are made very thin, and are consequently mounted on an extra thick block of wood. The separate moulding of the blocks and casting type high, or the mounting of them upon solid metal bases, is so easy that there is scarcely an excuse for being so unfair to the workman as to send pages containing wood-mounted blocks when a stereotype is required in a minimum of time.

Probably the interfering influence of the wood mount is largely responsible for the tradition that the paper process is unsuited for the reproduction of the finest engraved work, but if all or most reasonable precautions[*] are taken to ensure the very best results, stereotypes can be made by the paper process which are equal in fineness of surface and definition to the best electrotypes, and are superior in durability to many of the very thin shells of copper on a base of very soft metal, which pass nowadays. The paper process is, however, very ill adapted for moulding direct from wood cuts, owing to the action of the heat and moisture on the wood; and it is seldom employed for this purpose unless in the case of very small blocks, or when time necessitates it. The stereotype by the paper process is, when at its best, smooth, brilliant, and lustrous on the face, where the metal takes the impress of the compressed and hardened matrix; while the low parts, which are cast in contact with the spongy part of the mould, are always rough and often unsound in the sense of being permeated by holes and faults. The depths are nicely rounded and the square shoulders of the type-shanks show not at all, or only faintly.

Moisture in the Mould.—In all ordinary stereotyping work some moisture remains in the mould. It is possible to make a fairly sharp cast in a mould which is quite wet. By using a fusible metal (1 part cadmium, 2 tin, 4 lead, and 7 bismuth), which melts considerably under the boiling point of water—say between 60° and 70° C.—a very fairly good cast is obtained, the heat not being sufficient to convert the water into steam. This experiment is interesting, not only as showing a possible means of making a stereotype in a shorter period than the usual time—although the high price of bismuth tends to put it outside practical work—but also as illustrating a point of some importance, that, in the case of a mould not very thoroughly dried, the best result is obtained with the metal at as low a temperature as practicable, whereas in the case of a mould baked for a long time, the hotter the metal is, the better the result, provided it just stops short of burning the paper; so it is possible to have failures either from the metal being too hot or too cold. The use of French chalk on the face of the mould tends to minimise the mischief resulting from traces of moisture in the mould, but as it invariably makes the face of the cast a little rough, it should only be used when needed. Another use of French chalk is when numerous casts are required from the same mould, as it tends to prevent adhesion between the cast and the mould. When a large number of casts are required from one mould, other precautions to be observed are to use a well-cemented and ripened flong which is not too soft, to avoid making the mould too deep, and to beat with numerous gentle blows, rather than with a smaller number of heavy blows, as this tends to give a mould in which the depths are nicely rounded off, and do not follow the nearly vertical sides of the type face. Again, patches of old mould, or pieces of thin sheet metal, may be laid in the more considerable depths of the forme, so as to support the flong where subject to the greatest strain. Some stereotypers do this in the case of most ordinary work, while those who have a difficulty in beating the flong without shifting it, do the same in the case of all very open formes.

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[*] Such as clean and evenly but slightly oiled original; well united, thoroughly seasoned, and rather dry flong; drying thoroughly in the press with occasional tightening up; long baking of the mould; non-use of French chalk; a suitable hard metal—say the tin alloy mentioned—and this at as high a temperature as the mould will bear; and a considerable "head" and margin of metal in casting, the margin being of the full thickness of the gauges.

Inserting Blocks (Half-tone or Electro) in Stereo Plates.—The half-tone, during moulding, is to be left on its mount—the mould being done as far as the drying. Lay the half-tone in its proper position, and place on it pieces of wood the size of the block or corresponding to the pinholes; then paste them on the plate. The wood must of course be of the correct thickness to be held firmly between the lid and the mould. Care must be taken not to buckle the mould by using too much pressure—only enough to hold the pieces in place, and thus to stand the weight of metal in the pouring. It will be found, when cast, that the shrinkage of the metal holds the wood firmly. Fasten the half-tone plate on the wood in the usual way. In the case of electros, insert dummy plates in the moulds, and afterwards replace by the electros.

Stereotyping Half-Tone Blocks and Type combined.—If the blocks are not too fine, good results can be obtained. The flong must be of the best, with a blotting back and a fine face paper, it must be free from grit, have no creasing in the respective layers, and French chalk must not be used. Make the zinco higher with very hard thick card—this prevents shrinkage of the wood mount, which is fatal to success.

Stereotyping from Mixed Type and Wood.—Produce a strong adhesive flong by adding a little more glue, and take extra care in applying the face papers. This flong must not be new, and should be fairly dry. Thoroughly clean the wood portions, as any ink, etc., left on surface or in cracks will come out under the heat and ruin the mould. Oil as usual, but use sparingly on the wood. Beat flong as usual. Get casting box very hot, the lid to be same temperature as the bottom, which prevents the steam from flong being condensed and falling back on the mould. All blankets to be well dried—when flong has hardened, take the first blanket away and replace by a hot one. The mould can be lifted after applying a third blanket, and slowly dried on the casting box.

Bookbinder's Stereotypes.—For gold letter blocking bookbinders frequently require a good stereo. A harder metal is required, such as that produced by type metal without the admixture of lead. As this chills very rapidly, keep the casting box hotter than for usual stereotyping, using an extra brown paper sheet at back of mould, sufficiently long to reach the bottom, and this will keep metal fluid. The mould must be dry, not too deep, and the metal poured in at a good heat. In order that the cast may properly set, take care the lid is not lifted too soon.

Notes on Mounting.—A drill of the right size should be used for making screw and pin holes. Holes should not be punched through hard plates. When mounting on wood, note the run of the grain, in order that easy planing all round may be ensured. Obtain exact right angles by the use of the square-edge. Be sure that the knife of the plane is set at the proper angle to its bed—test it on spare pieces of wood, gradually altering the blade to suit. When squaring the mounted plate, start with the straight way of the grain at the longest side, making one sweeping cut with the plane; long, clean shaves prevent unevenness and irregularity, and save much trouble in printing, such as lifting of spaces, etc.

Damage to Type.—The question of damage to type during the process of stereotyping is one of some importance, and it mainly steps in when a high temperature is employed for drying. If the forme is very tightly locked up in the chase it may, in expanding and softening under the heat, become elongated, while, on the other hand, it may become shortened by the pressure of the drying press. These two circumstances tend to make a newspaper fount become of unequal height, and the fount is rendered useless.

Let the formes be locked with only a moderate force, sufficient to secure safe lifting. With the enormous power at the operator's command, only a slight turn of the wrench produces enough pressure on the type to secure this end—which may be verified by experiment—and then loosen the formes as soon as they are placed on the hot stereotyping bed, so as to allow for expansion. When possible, lifting the formes at all should be dispensed with: they should be imposed and then slid along on a continuous bed or imposing surface right on to the moulding bed, so as to avoid all possibility of accident. With such convenience at command, there would be no necessity at all for excessively powerful locking apparatus, and the ordinary wooden quoin and sidestick would be found sufficient. We strongly advocate the insertion of wood furniture—say about two-line pica reglet—between the long side-stick and the type; for, in case of undue expansion of the type in the process of moulding for stereotyping, the wood would give way before the metal type, and the latter would therefore be preserved.

Stereo Metal. — Good metal should show, when fractured, bright crystalline edges. This indicates the presence of antimony, a most important constituent, giving hardness and sharpness to the cast. Stereo metal can be obtained ready made; but a good metal can be made from old type and lead from linings of tea-chests. Frequent melting causes brittleness of metal, which is rectified by moderate dilution with tea lead. For cleansing metal, it should be brought to a heat sufficiently high to scorch to a deep brown, but not burn, a piece of thick paper when dipped into it. The mill should then be constantly stirred with the skimmer. A flux, consisting of a small quantity of crystals of borax, in stout brown paper, should be immersed, and soon after a little resin thrown in; well stir, and remove scum. The metal should then show a bright silvery surface, and be ready for casting.

Storing Moulds.—It is sometimes desirable to mould work in case of a future demand. Now it is a very easy and inexpensive thing to mould formes immediately they come from the machine, and to keep the moulds in case of future need. Take the formes of a 16-page publication; a set of light metal frames fit in the gutters so as to bring these up to the level of the face of the type. The pieces of flong—each corresponding to a page, with the necessary margin—may be rather over-dry than moist; with them you can mould a page at a time, and not many seconds are required for moulding each page, while as each mould is made it is lifted off and set aside. The formes need not even be washed, as the remaining ink does no harm in this case; and the moulds being removed at once, there would be but little risk of adhesion, even if there were not a trace of ink on the type. The damp moulds are now laid between quires of rough paper, this being sufficient to keep them flat during the time of drying, which may be several days. When dry, they are stored away in bundles. In casting from one of these moulds a few pieces of old mould are pasted into the hollows at the back, and the brown paper flap is pasted as usual on that edge which is to be the top, but the extra thickness of brown paper at the back is dispensed with. In some newspaper offices it is the practice to take the moulds off some of the earlier pages while wet, and dry them separately. When the mould is removed wet, there is a contraction of about $\frac{1}{130}$ linear.

Plaster Process.—In this, the older but now less used process, the moulds are formed of plaster of Paris. By this method the castings produced have much sharper and deeper outlines; on the other hand, the mould produces one casting only, the operation occupies a longer time, and requires a large and expensive plant.

Apparatus.—The metal-pot, of a convenient size for immersing the dipping pans, is best fixed against a wall, to facilitate handling the pans by means of a crane. The oven for baking the mould may adjoin the melting pot, and be fitted with several shelves. A good arrangement is an ordinary low brick furnace surmounted by a square oven about 3 ft. wide and 4 to 5 ft. high, bricked in, and having the furnace flue carried round the back and sides. The door covers the whole front of the oven, and an iron shelf to 10 in. wide is fixed beneath it on a level with the bottom shelf, for convenience in sliding the articles in and out. The floor of the oven should be reserved for heating pans and plates before casting, and never for baking the plaster moulds, as its temperature is unequal, and would cause uneven shrinkage and consequent destruction of the mould.

The plates are cast in dipping pans (Fig. 153), 3 to 4 in. deep, oblong, and with sloping sides, on which are sockets *a* to admit the clamps by which the pans are swung from the crane. The cover *b* may be flat or slightly domed, the corners *c* being cut off to admit the metal. The lid is held in place by the screw *d* and the hinged clamp *e*. The floating plate, of ½-in. iron, fits loosely into the dipping pan.

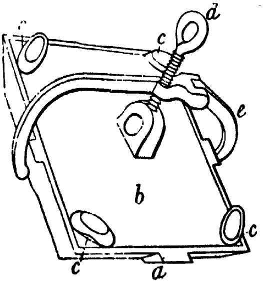

FIG. 153.

The trough for cooling the dipping pan and its contents is placed beside the metal-pot, in a position to admit of the crane easily depositing its charge. It should be about 4 ft. long and 2 ft. wide, and stand slightly below the top of the metal-pot; four iron bars, ¾ in. thick and 2 in. wide, are fixed across, sufficiently near each other to allow of two dipping pans being placed on them at one time. A few pieces of thick flannel, or similar substance, secured round the bars will admit of the moisture being communicated gradually to the hot pan, Some molten metal frequently falls into the trough from the corners of the dipping pan during suspension, and from the ladle while filling; the trough should be cleaned up at intervals, and the cleanings thrown into the metal-pot, but not while the metal contained in it is heated. A good plan is to sweep the foundry and clean out the cooling trough every night, and to transfer the sweepings to the metal-pot, ready for melting on the following morning.

The plaster matrix is taken from the forme in a moulding frame, which in appearance bears a close resemblance to an ordinary chase; but the four sides facing the type are bevelled inwards, so that when the plaster hardens it is equally supported on all sides.

The formes are placed for moulding on an iron surface fixed against a wall. It should be long enough for several moulds to be prepared in immediate succession. The iron surface may be replaced by a slab of stereo metal, 1 in. thick, well planed on the surface, and arranged along an ordinary wooden balk; in this latter case, the surface of the slab should be frequently examined to ascertain whether there are any indentations, which would necessitate their being either replaned or discarded, as the type might sink into the cavities when planed down, and render the mould imperfect.

The dipping pan, after cooling, is placed on a block 4 ft. high and 3 ft. wide, where the mould is knocked out of the pan, the corners of the cast are detached by the mallet, and the plate is thus set free.

Brushes are needed for cleaning the type, removing the plaster from the surface, and oiling; small steel straight-edges, for taking off the superfluous plaster from the back of the newly-made mould; chisels, for raising the moulding frames from the forme, and releasing the plate from the metal; a strong barrel, with lid, for the storage of plaster in a dry place; and several tin cans for mixing the composition.

Preparing the Metal. — Several recipes for the composition of alloys for casting stereotype plates will be found under the heading of "Alloys" (Volume I.) In general terms it consists of lead with about 12 to 18 per cent. of antimony added to produce the necessary degree of hardness. It may be bought in blocks ready for use, which is the better plan in all but large establishments, as some skill is required to ensure making a good quality of metal, and without that quality satisfactory work is impossible. The furnace and pot for melting the metals and making the alloy, as well as for heating the metal ready for casting, should be completely encased in a hood of sheet iron, with a flue leading from the top, which flue may be utilised for conveying a certain amount of heat to the drying oven. The hood must have a door in the front to permit the metal to be stirred, skimmed, and ladled out.

Before making the alloy the lead is melted alone first, and thoroughly freed from the dirt and dross which collect on the surface, by means of a skimmer, consisting of a disc of perforated sheet iron with a rim and short handle. The addition of a small quantity of oil or grease to the molten metal will much facilitate the liberation and removal of the dross. When the lead is perfectly clean, it is cast into blocks ready for remelting to make the alloy.

In conducting this latter operation the lead is again placed first in the pot, melted, and well skimmed, taking especial care that no zinc is allowed to contaminate it. When quite clean, the proper proportion of antimony is added, that being, for every 100 lb. of lead, 18 lb. for the plaster process, but only 12 lb. for the paper process. If the molten alloy, after being well stirred to mingle the two metals, be found to exhibit a tendency to adhere to the sides of the pot and to the tools plunged into it, this may be taken as a sign of poor quality and the necessity for adding more antimony. Having secured a good quality of metal, it will be fit for casting at about 600° F. (316° C.). Experienced workmen estimate the temperature by holding the hand at a distance above the pot, instead of having recourse to a pyrometer, but a novice would need to resort to the more scientific method until accustomed to judge of the heat.

In making stereotyping metal in the foundry a quantity should be mixed at one time, as the plaster process demands much material always in use. The manufacture of the alloy considerably interferes with the casting, and the dipping should never be commenced without a sufficient supply being available. In most foundries where mixing is carried on to any extent, a separate pot is provided for the purpose, taking care that it is well closed in by an iron hood, before described, just sufficient opening being left for the long iron for mixing.

The broken metal, if of good quality, should present a sparkling appearance ; if it is dull, sufficient antimony has not been added, and plates made from such metal will lack sharpness of outline.

Preparing the Forme.—The first step is to subdivide the forme, if possible, so as to have plates of minimum size. The forme is laid on the imposing surface, unlocked, slightly damped, and re-imposed in smaller chases with type-high clumps to replace the furniture round the pages, noting that the lower side of the clumps must come next to the type. Every caution must be observed to prevent types falling out, and to ensure the matter being securely locked up and level.

Low spaces and quads must all be raised to the level of the height of the shanks of the letters prior to moulding ; therefore it is desirable to employ high-spaced founts when plaster casts are to be taken. Besides being originally more costly, however, the high spaces would be a source of much trouble if the type should be required for working from.

"Filling-up" is effected by pouring plaster having a pasty consistence over the surface of the forme, and rubbing it down by hand. When this has been evenly and thoroughly performed, and before the plaster has completely set, the whole is gone over with a moderately stiff brush, to remove the plaster from the beards of the letters.

The pages having been examined for imperfections, the forme is set to dry thoroughly in a rack specially provided. If a number of formes are to be cast, it is well to fill them all at one time. The plaster being dry, the forme is laid on the imposing surface, which must be perfectly clean, and the face is again brushed, so that any small detached crumbs of plaster may be cleared away.

Before oiling it is absolutely essential that the face of the type be both clean and dry. When this is the case, carefully apply some olive oil on a soft brush, sometimes adding a small proportion of turps if the oil is very thick. The oil must adhere in every part, or the cast will come away in an imperfect condition—pieces of plaster remaining attached to the unoiled spots. The oil answers a double purpose, preventing the adhesion of the mould to the type, as well as hindering the moisture of the fresh composition from affecting the plaster already used in filling up the forme.

Casting the Mould.—On the locking-up furniture round the type are placed pieces of tin about 1½ in. wide and of various lengths, destined to provide a perfectly flat surface for the casting frame, and to stop the thin plaster from running. The casting frame is adjusted in position round the pages, after the sides have been oiled. Then in an iron or tin pot kept for the purpose is mixed a sufficiency of plaster to a creamy consistence ; this is poured upon the face of the type and carefully forced in by a pad of folded blanket, called a "dabber." In this way the air is expelled from between the plaster and the face of the type. Then more pasty plaster is added, and well rubbed in by hand, to ensure the plaster occupying the smallest interstices, when the surface of the type will be completely covered with a film of plaster.

Next a further quantity of the composition is mixed somewhat thicker, and enough of it is poured on the forme to entirely fill the casting frame. As the plaster hardens very rapidly, every means must be taken to prevent small lumps from forming, both on the hands and in the mixing-pot; after each operation the hands and pot should be well washed. Whilst the plaster remains liquid the surface is scraped with a straight-edge level with the top of the casting frame, after which the mould is allowed to stand for five minutes; by this time it will have partially hardened, when the back may be scraped again. Should the mould not be of uniform thickness throughout, it is apt to be cracked by the pressure of the molten metal in the dipping-pan. Success is almost entirely dependent upon the quality and manipulation of the plaster.

Removing the Mould.—When the mould has stood some 15 to 20 minutes it should have become sufficiently firm for lifting from the type. Forked tools with short handles are used for this purpose, one in each hand, the points being carefully inserted between the casting frame and the chase. The operation demands the gentlest care; if force is exerted unevenly small portions of plaster will break off and spoil the mould. After detaching one end of the frame, the other end is loosened in the same manner; then the whole can be lifted off the forme, being supported by the protruding bevel of the casting frame. After removal of the mould the type should present a perfectly clean face, not a particle of plaster appearing among the type.

Baking the Mould.—When the mould has stood for a few minutes, with the aid of a knife cut a small groove round the back towards the iron frame. Turn the mould on its back and lightly tap the frame, when the plaster will drop out in its entirety. Superfluous plaster is trimmed off with the knife, and notches are cut on the top sides of the plaster rim, that the molten metal may gain admission to the face when put into the dipping pan.

The plaster cast is next baked in the oven, whose proper heat is about 400° F. (204° C.). The mould is introduced between two of the partitions in the oven on its side, and allowed to remain for about 1½ hour, by which time it will have become sufficiently baked, and will assume a brownish hue. Meantime the dipping pot and floating plate are likewise put into the oven, on the bottom shelf, in order that they may attain the same heat as the mould.

Testing the Metal.—Before pouring it is necessary to test the metal, as unless it is hot enough it will not flow freely under the cast, and the plates will lack sharpness or become chilled; if too hot, the mould is liable to crack when immersed. The test mostly applied is that of inserting a piece of paper in the metal, when the paper should acquire a straw colour. If the metal is too hot, the draught of the fire must be reduced or a little cold metal added. The dipping pot or casting pan, when sufficiently heated, is slid along the iron shelf to the front of the metal pot, and the floating plate, which is of the same size as the bottom of the pan, is put inside, the workman being provided with pads of thick flannel while handling them.

Casting the Plate.—The first precaution is to ensure that the pan, plate, and mould are of nearly one uniform temperature: if the plate is colder than the cast it will cause a sudden contraction of the latter; if warmer a sudden expansion, either of which will probably crack or warp it. Some workmen prefer to heat the floating plate by immersion in the molten metal. There must be no delay between placing the dipping pot in position, the floating plate inside, the mould on the top, and fastening the lid. After removing the cast from the oven, should anything unforeseen occur to prevent its being immediately placed in the dipping pot it must be put back in the oven till heated again, together with the pot and plate.

Should the cast be much smaller than the floating plate, small plaster cubes, previously prepared, may be placed round the sides to prevent it moving about in the pan. The cover is next put on and secured by means of the clamps and screw, the clamps attached to the chain on the crane being fastened into the sockets on the side of the pan. The ratchet is wound up and the whole is swung above the metal pot, then gently lowered until the top is on a level with the surface of the metal. By tilting the clamps with one hand the side of the dipping pan is gently dipped at one corner into the metal, allowing the latter to flow in only at one corner, so that the air may be driven out at the other openings, the pan being entirely immersed only after all the air has been expelled. When the pan is full, gently lower the whole into the metal, allowing it to rest on the bottom of the pot. Care must be taken that the metal in the melting pot is not allowed to run too low, so as to ensure that when the mould is placed ready for dipping there is sufficient metal to cover the top of the pan.

When new metal is added to the pot the temperature of the mass will be considerably lowered, and no cast should ever be made without first testing the temperature.

By its greater specific gravity the molten metal presses up the floating plate and the mould to the lid of the dipping pan, and forces itself through the notches cut in the side of the plaster into every part of the mould. The pan should remain in the metal for about ten minutes, during which time the floating plate for the next casting may be placed in the metal, allowing sufficient to remain above the surface to enable the operator to obtain a firm hold for its removal.

Cooling the Cast.—When the pan has remained in the metal for the time stated it should be gently raised, swung round to the cooling trough, and allowed to rest on the supports made for the purpose. Care must be taken that it be swung in a perfectly horizontal position, or the metal will be liable to flow to one side and thus render the thickness of plate uneven. As the metal cools it contracts considerably, and more metal must be poured in at the corners of the dipping pan to make up the deficiency, and to exert the necessary uniform pressure on the cast. This pouring must be repeated several times during the cooling. As the water in the trough sinks owing to the rapid evaporation, further supplies should occasionally be added to maintain the required level. The cooling of the cast (which properly occupies about 20 minutes) must not be hurried, or the mould will split, and the metal will run into the crack. If the cooling operation is hastened in the slightest degree the sudden contraction of the metal on the surface of the newly-formed plate will cause the letters to lose their clearness of outline. The water in the trough should be high enough to saturate the pieces of blanket, but it must not be allowed to touch the pan bottom.

Knocking out the Plate.—When the pan has completed its cooling it is lifted on to the knocking-out block; then loosen the clamps, and remove the lid by inserting a strong chisel at the corners. Turn the pan upside down, and give a smart blow with the mallet on the bottom, when a block of apparently solid metal will drop out. Let it stand for a few minutes to allow it to become still colder, then turn again, the widest part uppermost. When the metal is sufficiently chilled strike off the extreme corners with a mallet, being careful to hit away from the bulk. Next break away the sides, striking from the top, and, as before, away from the body of the metal, or the plate will be injured.

After all the edges round the top are struck off, the thin metallic covering of the mould can be removed, and the whole of the plaster will be exposed to view. This can be picked from the surface of the cast, and the latter be lifted from the floating plate.

It is wise to wear a leather apron, to provide against the effects of metal splashing; some thick blanket-pads should be provided to enable the workman to safely handle the hot dipping-pans, floating plates, etc.

Should any plaster adhere firmly to the detached pieces of metal, the whole may be thrown into the melting pot, when the plaster will rise to the surface, and can be skimmed off with the ladle.

If the cast is perfect, superfluous metal is cut away and the plate finished. More work is entailed in finishing a plaster plate than in the paper process, incurring additional items of expense.

Flattening the Plate. — In consequence of the unequal contraction of the metal on the face and back of the cast, before finishing in the ordinary way the plate needs to be "flattened." Having trimmed the superfluous metal from the sides, etc., run a small straight-edge over the face, when indentations may easily be seen. Mark these places with a pair of callipers on the back, and then with a planer or burnishing hammer knock them up to the required height. A piece of thick brown paper or thin flannel must be placed between the beating surface and the face of the plate, or the latter may get injured.

Turning to Uniform Thickness.—The back of the plate is sure to be somewhat rugged, and probably extremely uneven. It is therefore necessary, before planing smooth, to turn the plate to a uniform thickness in a lathe made specially for the purpose. This consists of a large thick disc, working on a short shaft; four adjustable toothed chucks or "dogs" lie upon the surface, and can be moved to any position towards the centre of the disc by the turning of a screw-head in the flange of the wheel. In front, and parallel with the disc, is a slide, upon which is fastened a carriage provided with adjustable knives. After the plate is fixed to the large disc or wheel by the chucks the machine is set in motion, and, as the plate revolves, the carriage and knives move slowly along toward the centre of the disc. By this means a regulated thickness of metal is taken off in circular strips. A piece of thin brown paper is laid between the faces of the disc and the plate to prevent any injury to the latter by rubbing when it is being secured. When fixing it is essential to place the plate as near the centre of the wheel as possible, and to tap or press it closely to the surface; if this be neglected it may be springy when screwed up, which will cause the metal to be taken off to an unequal degree. On the other hand, the chucks must not be screwed up too lightly, or the same defect will occur, and the plate be insecure. Just sufficient force should be exerted in securing the plate to prevent the possibility of its being jerked off while being turned.

Planing the Back.—Before placing the turned plate in the planing machine the angles of the top and bottom edges of the back of the plate need filing off a little, so as to enable the plane to catch the metal fairly. The machine must be adjusted with accuracy so as to reduce the thickness of the plate to a small pica, always allowing for the sheet of paper which must be interposed between the face of the plate and the bed of the planing machine. This planing process is not always carried out, but its advantages are obvious in saving labour when the plate has to be made ready for printing from.

A handy form of planing machine is shown in Fig. 154. It consists of a long iron bed *a* working backwards and forwards on a long screw *b* running beneath. The knife *c* is fastened at a slight inclination in a frame *d* fixed across the centre of the bed. The plate is laid face downwards on the bed, and a thick iron wedge is forced by the workman on the back of the plate. By revolving the capstan wheel *e* the plate is gradually driven under the knife, by which a slice of metal is taken off and the plate reduced to a uniform thickness and even surface.

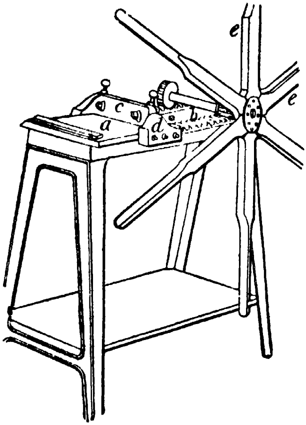

FIG. 154.

Bevelling and Squaring the Plate.—The planing has rendered the plate true as regards its faces. The next step is to adjust its edges. An accurate gauge should be used, each size of type page requiring a separate gauge. The plate is laid on a flat narrow iron table, arranged to run on slides, fixed to a very firm bench, with a planing iron secured in juxtaposition. The plate is laid on its back and covered with a piece of stout blanket, on which a screw platen descends to hold it in position. The plate having been correctly gauged, the edges are accurately planed off to the gauge, and then as carefully bevelled at the margin. Where operations are conducted on such a large scale that hand labour would be inadmissible, some form of planing and bevelling machine may be used, operating by means of revolving cutter discs, a hood being fitted over the work to collect the flying particles of metal. A small gas engine or water motor is handy for driving the machines.

Mounting the Plate.—If the plate is to be mounted on a wooden base the bevelling can be dispensed with, the plate merely requiring to be trimmed square and almost flush with the type. The best wood for mounting on is well-planed pine; the plate is thoroughly secured by driving ½-in. French nails through the metal and into the wood, punching them down flush with the metal.

Stereotyping has been largely adopted in newspaper work as saving much labour where the same item of news has to be sent to perhaps a dozen or more different papers. In this case, plates of the items are cast in the required number and distributed. To reduce the heavy cost of transport entailed by using the ordinary massive plates, the impression is taken in sheets of metal of only just sufficient thickness to afford a printing surface and ensure freedom from liability to breakage by rough handling. Then this metallic printing surface, which will be recognised as the essentially valuable part of the stereotype plate, is mounted either on wooden lengths, of the proper thickness, and secured by nails, or recourse may be had to the metallic block system, in which the plate is cast with an undercut projection corresponding with a groove in the block which is to make up the necessary type height. The blocks are cast in columns, and afterwards cut into pieces varying from ½ in. to 18 in. in length, for convenience of making up into columns. The plates are locked to the blocks by column rules. Obviously the same principle may be carried out with any suitable method of uniting the plates and blocks.

It is a matter of convenience to cast the "risers" or movable blocks for mounting plates on the premises. They are usually made square, with indentations at the sides for reception of the brass catches, as in Fig. 155, which measures 3 in. long and 1½ in.

square, other sizes being also made. The side clumps, Fig. 156, are made either 1½ or 3 in. long, and 1 pica thick. The blocks should be cast hollow to save metal. The catches, Fig. 157, are made of brass rule, and can easily be produced on the premises by getting long strips cast with the required flange, then cutting up as needed, filing quite smooth, and drilling the necessary holes for admitting the pin that holds all secure.

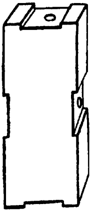

FIG. 155.

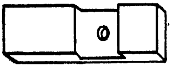

FIG. 156

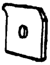

FIG. 157.

Perfecting the Plate.—After all the preceding processes the plate is very carefully inspected for minor imperfections. Of course, anything like a serious imperfection is quite sufficient to condemn the plate entirely, and necessitate its being redone from the beginning; but small matters may be remedied. Among these are spots where the metal in the "whites" comes too high and would be in danger of taking the ink in printing; such must be chipped away with a sharp chisel. Again, individual letters may be battered; these require to be drilled out, a new type letter being dropped into the hole thus made, and secured by soldering from the back.

Moulding from the Plate.—Before taking a cast from a stereotype plate its type surface must be very thoroughly cleaned with a brush and some strong soda solution, as for washing ordinary type, to remove accumulated dirt. It is then dried well, and the face is oiled, as in casting from type. The plate is next laid on the moulding table, tin side pieces being unnecessary. The mould is taken in the ordinary way, and when dry enough it is turned on its back, and the plate is gently raised from it. Thus the mould is left till ready for trimming and the other usual processes that follow.

Plates taken in plaster suffer a much greater degree of contraction than those taken by the paper process, in consequence of the shrinkage of the mould in baking and dipping, while the type is not present to offer any resistance. The amount of shrinkage in a crown 4to page is about $\frac{1}{12}$ inch in length, and $\frac{1}{24}$ inch in width.

* * *

STONE.

ARTIFICIAL AND BUILDING BLOCKS

(*See also* CEMENTS, CONCRETE, PAVEMENTS, POTTERY, SLAG, ETC.)

BY artificial stone is meant a composition, which is usually composed of sand or crushed stone, made into a hard mass by means of cement. There are now, however, chemical actions or additions to be relied on making some very sound and reliable building or paving materials, as will be seen. A good kind of artificial marble is described.

Artificial Paving-flags.—These are made of a concrete composed of granite chippings, not larger than ¾ in. gauge, well washed and mixed with clean washed sand and Portland cement (well aired and not too new). The proportions are 2 of chippings, 1 of sand and 1 of cement, well mixed while dry and then wetted with water delivered through a rose. Only sufficient water should be used to properly moisten the whole, as too pasty a mass does not lend itself to good moulding.

Moulds are made of wood, lined with zinc to give sharp arrises. To prevent the concrete sticking to the moulds, soft soap, linseed oil or vaseline is used. The moist mixture is shovelled into the mould, a little at the time, and spread by two men with trowels. When the mould is full the top surface is smoothed over with a flat and patted until a cream comes to the top. In large works a machine is used to rapidly shake the moulds to ensure the concrete settling down into a solid mass.

The moulded slab is allowed two days to set (in the mould), then carefully removed and stacked to dry slowly. The air should get all round each slab, and at least a week is allowed for drying.

The next process, when required, is to put the slabs through the silica bath, this hardening and greatly improving the quality of the slabs. The silicate used is that known as water-glass. Silica itself is a very hard and refractory material, but in the presence of soda it melts readily, according to the quantity of soda used, until not only is its melting point reduced, but, when fused with an excess of soda, it actually becomes a soluble material. Commercially it can be purchased in a state resembling a soft size, and when diluted with water to a strength showing 1250 or 1300 on the hydrometer it makes a bath suited for treating concrete slabs. The slabs are soaked in this for from a week to ten days, and after being drained, are then stacked away to mature for three or four months. They improve and become stronger with keeping.

Artificial Stone for Moulded or Shaped Objects.—This is made of a concrete composed of 1 part good Portland cement, 1 of sand and 2 of broken stone or granite chippings. The gauge of the latter should be from ⅛ in. to ⅜ in. according to the size or bulk of the object to be formed. All ingredients are well mixed while dry, then moistened with water sprinkled over with a rose. The moulds may be of beechwood, but if the shape will admit they should be lined with zinc. Metal moulds are best if the quantity of articles to be made is great enough to warrant the cost, while plaster moulds (made from a clay model) may be used for small numbers of intricate design. Soft soap, linseed oil or vaseline is used to prevent the cement adhering to the mould. The concrete should be well worked, pressed or shaken into the mould, and be allowed four days to one week in the mould to set. After this they should be allowed ten to fourteen days to dry. If they are to be treated with silica, this can then be done as with the preceding or the following recipe, but whether so treated or not, the articles should then be stacked away some months to mature and properly harden.

Silicating or "Petrifying" Liquid for Concrete, etc.—(*a*) Soluble silica can be made by digesting pure flint (silica) with caustic soda, under pressure and high temperature in an air-tight vessel, such as the Papin's digester. The strength of the silicate should be 140° (T), showing 1700 on the hydrometer. For use water is added until the mixture shows 1250 to 1300 on the hydrometer. It is then a clear fluid, somewhat copper coloured. This forms a dip for concrete flags or other objects; the effect being to fill the pores with flint, which soon sets and makes a hard stone compound. Concrete and cement floors can be treated by pouring the liquid over and working it in.

(*b*) There are two ways of preparing soluble silica or water-glass. The easiest is by fusion, mixing together 10 parts of dried carbonate of potash (or 15 parts of dried carbonate of soda), 15 parts of fine quartz, and 1 part of powdered charcoal, and fusing these together in a plumbago crucible. The resulting mass is soluble in water. It may also be prepared by making a saturated solution of caustic soda, placing this in a cast-iron vessel, along with nodules of flint, and boiling the whole together, under a pressure of 60 lb. to the square inch, until the soda has combined with as much silica as it can take up. This is known by its losing its alkaline taste and its acquiring a somewhat sweetish savour. This latter method is only possible on a rather large scale, as special appliances are required.

Building Blocks of Hollow Concrete.—Writing of the use of hollow concrete blocks for building purposes, the 'Engineering Times' points out that their use is becoming greater every day, the increase being so great that whereas five years ago they were practically unknown, there are now no less than 150 different machines for producing the blocks, and a still greater number of firms making them. There are several causes of this sudden development of the industry, not the least being high wages, lower cost of good cement, and the fact that much timber may be saved. The blocks are made of a variety of sizes and shapes, and of materials and in proportions innumerable, sometimes of one piece for a section of wall, and again in two pieces (outside and inside). Single blocks are made as large as 8 ft. long, and 8 in. wide, and 10 in. thick, reinforced by steel rods. Blocks are rarely made longer than 6 ft. without reinforcement. Single-piece hollow blocks are made 20 in. long by 8 in., 9 in., and 12 in., other dimensions, so as to make the full thickness of the wall. Two-piece blocks are made, as the name implies, for face and back wall. An argument in favour of the single-piece block is that when laid in place a section of the wall is completed, requiring no bonding to the front, containing 30 per cent. air space generally; more material and strength, therefore better and more economical than two-piece system. Advocates of two-piece system claim to secure a drier inside wall, with less material, having 50 per cent. air space and a more even inside wall on which to plaster.

Following are a few of the proportions of material used by different makers of blocks: 1 cement, 4 sand; 1 cement, 4 sand, and gravel; 1 cement, 5 sand; 1 cement, 2 sand, 4 cinder; 1 cement, 1 sand, 2 crushed stone; 1 cement, 3 sand; 1 cement, 2 sand. The concrete becomes practically waterproof when set, and thoroughly crystallised. After the materials are mixed dry, water should be added from a sprinkling can till the mass is of a uniform colour and sufficiently wet to retain shape when squeezed in the hand. The quantity of water required will vary with the condition of the sand and the percentage of humidity in the atmosphere. Shovel the mixture into the mould in small quantities, meanwhile constantly tamping. Remove the block on the plattern to a place under cover, and allow to remain for at least one week (two weeks shows greater strength); sprinkle the block next morning and twice daily for one week, when the block may be safely used in building.

One firm employing twenty-five men making hollow blocks supplied them to eighty-six dwellings and three large factories in three summer months. These were generally sent out less than a week old, and rarely watered more than six times before placing in the yard exposed to the sun's action. No failures have so far accrued, and demand exceeds production, showing that satisfaction has been given to architects and builders. One peculiar feature of the business is the favour shown for blocks with an imitation rock face, which is so palpable an imitation of stone work that it is repellent. A neat appearance is given by a plain or tooled face. The material is so well adapted to many uses and designs that it deserves a better fate than being considered an imitation of something else. Let it stand for what it is, the best of building materials. The solid wall, or so called monolith style of concrete building construction being an established fact, why should not the block business thrive? The block being made in smaller units are less liable to contain defects than a large mass. The most beautiful architectural effects may be secured by using moulds for solid or monolith work, and surely the same ingenuity may be developed with hollow blocks. Fire protection is perfect; the material being practically indestructible. And one must further consider the cheapness and ease of construction; with one good mason and a fair quality of labouring men, an ordinary plain building may be erected of as durable a character as the most skilled and high-priced men could build, in many cases at less cost than a brick structure and in some cases less than a frame building.

Silica-Lime Building Stones. The name implies that the stones are made up of silica (sand) and lime. The basis of this process is a chemical combination between lime and silica, making a very hard stone. The true value of the chemical combination and the resulting stone is that it is proof against all ordinary destructive agencies much as flint-glass is.

Three processes have been adopted: (1) that of using a lime paste, the lime being first slaked, then made into a cream and allowed to settle into a paste; (2) the use of dry powdered slaked lime, and (3) the use of dry powdered quicklime. These are divided again, in a sense, into air hardening, hardening in chambers with low pressure steam, and hardening with high pressure steam.

While all may be considered practical, the best and most economical results are obtained with sand and dry quicklime hardened in chambers charged with high pressure steam. Less lime is employed and much less time, the former being a distinct saving in material, while the latter greatly reduces the size of the plant required to turn out a given quantity of work in a certain time. Air hardening takes weeks, depending on the weather; low pressure steam from three to four days, high pressure steam ten to fourteen hours. Thus a hardening chamber for the latter can be charged and emptied many times, while one charge would be hardening in low pressure steam. There are other minor points in which high pressure steam hardening gives best results, particularly as to the possibility of the finished stone wearing and lasting well.

The lime should be as pure as possible, the purer the better, and what is known as a fat lime can be used. The actual percentage of lime that can combine with the silica is no more than 2 or 3 per cent., but this will depend to a certain extent on the proportion of silica in the sand. Too much lime is detrimental as it cannot combine, and may, when exposed to the air, diminish the strength of the stone. A slight excess is, however, necessary, as it cannot be relied on that an exact percentage will be so precisely distributed as to act perfectly. In practice, from 6 to 9 per cent. of lime is requisite. The sand, as stated, must be rich in silica, the richer the better, and the sharper it is the better, the process requiring a mechanical as well as a chemical combination.

The chemical action between the two ingredients will not occur without moisture, and is greatly assisted by heat. The moisture must, however, be in correct proportion. Too little moisture makes the moulding of the stone difficult, and also prevents the proper slaking of the dry quicklime and consequent imperfect combination. Too much moisture causes difficulties in the moulding, as the material should not be pasty for this purpose. The best proportion of moisture is from 8 to 11 per cent.

To ensure the presence of the correct proportion of moisture, it is almost imperative, in large works, that the lime be burnt on the spot, be taken from the kiln and go through the grinding and mixing and ultimately join the sand, with little or no opportunity of absorbing moisture. The sand is dried (by one manufacturer) by putting it into the mixing machine first, this machine being heated and having a vacuum pump attached. This quickly extracts all the moisture. The lime is then introduced in proper quantity, and when the machine is closed and the mixing mechanism started, a measured quantity of hot water is introduced through a rose or sprinkler that is provided. It follows, then, that as the mixing proceeds, the lime becomes slaked, and this with the heat evolved in the slaking commences the chemical combination at once ; and it is doubtless this that helps to reduce the time taken by subsequent hardening process.

After mixing, the material is taken to the presses and there formed into bricks, moulded stones and ornaments or whatever is required. The press is sometimes of the hydraulic kind, particularly where quality is required more than speed, otherwise a mechanical press is used. It is in the press where the precise best percentage of moisture shows to advantage, for if too much water is used it is practically impossible to press the mass properly, whereas if too dry the pressure has to be greater, which means a smaller brick or stone of unnecessary weight.

Having obtained the pressed forms the last important process is the hardening, which is really the drying, which completes the chemical combination of the two ingredients. This, as stated, is done in high pressure steam, steam at a pressure of several atmospheres. The chambers in which this is done are constructed of wrought iron and resemble very large cylindrical boilers. One end is removable, forming a locking door, and through this the wagon loads of pressed bricks or stones are rolled on lines provided. The wagons are on low wheels, usually a simple platform on which the bricks are stacked, or they may be fitted with metal shelves, if the moulded articles require this. In the latter case the wagon cannot carry so many pieces, and there is a proportionate loss in economy. A chamber about 60 ft. long, by 6 ft. diameter, will take about 10,000 bricks (according to size). A very practical description of the processes, apparatus and plant for this work, is given in "Silico-calcareous Sandstones" by Ernst Stöffler, published by E. and F. N. Spon, Ltd.

Bricks of Cement and Ashes. Ashes can be used for making building blocks provided (1) they are free from lime (2) they have been exposed to the weather to wash out all salts and (3) that they are sifted to remove that part which is absolutely dust. 1 part of Portland cement to 5 parts of ashes will make a reliable block, but they should be pressed (as all bricks are) or they will be too porous. They are no cheaper than ordinary bricks if these latter are obtainable.

Scagliola or Imitation Marble.—This is not a surface finish (such as is described under "Marbling") but is made up of solid coloured material. The work can be made very beautiful if care and judgment be exercised, and properly done the substance is very like marble of the best decorative kinds. Much, however, depends on the making, as will be understood directly.

Take some best gypsum and calcine it until the masses have lost their sparkling appearance and become uniformly opaque, then grind and sift finely. This can be obtained ready prepared if required, being the best quality plaster-of-Paris. When about to be used it is made to a thin paste with a solution of glue or isinglass, or similar material which will retard its otherwise too rapid setting. If only one tint is required this is made up by mixing a suitable colouring ingredient, but to imitate the variegated colours of marble, a sufficient number of vessels have the plaster in them, each of a different colour. The different coloured materials are then roughly mixed (or combed) together and at once applied to the wall or object that is to be coated, the surface being floated smooth and then allowed to set hard.

The next and final process is to polish the surface. This is first done with pumice stone and water (the surface being wetted with a sponge) after which tripoli and charcoal are used with a piece of linen, and finally a piece of fine felt dipped in a mixture of oil and tripoli. It may last of all be gone over with oil only. Walls or large objects to be finished in this way have a surface of roughened plaster to receive the scagliola composition.

Grindstone, Artificial. — Washed silicious sand 3 parts, shellac 1 part; melt the lac, and mould in the sand, while warm. Emery may be substituted for sand. Used for razors and fine cutlery.

(2) Very hard and good. Powdered glass 59 parts, rock crystal 22 parts, minium 22 parts, calcined borax 14⅓ parts, saltpetre 5 parts, arsenic 1¼ parts. Mix with water to a paste and press into moulds.

Hardening of Soft Stone.— A process by means of which the softest sandstone or limestone can be made hard has been discovered by A. Kubelka. The following are the methods he employs. First, the surface of the stone must be thoroughly cleaned, so as to expose the pores. Any oil or grease spots must be removed with benzene or with the alcohol flame. Missing pieces must be filled up with cement mortar, using a 1 : 7 solution of waterglass for tempering. After the stone is thoroughly dry, it is saturated with a solution of potash or soda waterglass. In case of rain during or immediately after this operation, the stone must be again cleaned, dried, and saturated with the solution. Then follows an impregnation with molten chloride of calcium. After this, rain will do no more harm, as on account of the reaction of the chloride of calcium upon the solution of waterglass, the pores of the stone will be filled with insoluble, hard silicate of lime; while the soluble silicate of lime will be decomposed and washed out by rain.

Another method of Kubelka's is to saturate the stone first with a solution of sulphate of alumina in water, and when dry with a solution of potash waterglass. Sometimes a repetition of this process will be necessary to thoroughly fill all the pores of the stone. It is enough if the stone is saturated to a depth of about ⅛ in. Whitish brush marks may be cleaned either by rubbing with a piece of the same stone, or by refacing the stone, or by brushing with steel brushes. Should the solution not impregnate the stone quick enough, it must be diluted with more water. The solution should be entirely absorbed by the stone in about one minute. Whatever is left over on the surface after this time should be wiped away with a rag, as the crystals formed by the evaporation of the water would make a rubbing and cleaning of the stone necessary. A separate brush should be used for each solution, so that the reaction should begin in the pores of the stone. For larger surfaces atomisers or sprinklers may be used successfully.

* * *

STRAW PLAIT AND WOVEN MATTING.

THERE is so much similarity in the manufacture of these articles that they readily admit of description under a general heading.

Straw-plait.—In this industry, Tuscany holds a first place. All that which is known as Leghorn or Florence straw is raised on the hills which rise on each side of the rivers Pisa and Elsa, to the south-west of Florence. It requires a particular soil; in fact, its adaptability to the uses to which it is destined depends principally on the soil in which it is sown, which to all appearance exists only in this small district, out of the bounds of which the cultivation of straw is unknown.

The grain of several of the finest qualities of wheat, provided it be of the kind that has a hollow flexible stem, can be used for seed. The soil must be tilled and prepared very much as it is for corn, but the seed must be sown five times as thickly as what is usual for other purposes, either in December or February; in the latter case the crop is gathered later. When the straw is full grown, and just before the grain begins to form itself in the ear, which usually is during the months of May and June, it is uprooted and firmly tied, close to the roots, in little sheaves, each one about the size of a handful. Each little sheaf or *menata*, as it is called, is spread out in the shape of a fan to dry in the sun for three days, after which it is safely stowed away in barns.

After the harvest is over, and the fields are empty, it is again spread out to catch the heavy summer dews and to bleach in the sun, during which process every sheaf has to be carefully turned over every day, till it is equally white on both sides. Here the cultivator's work ends and the manufacturer's begins. But before we leave the strawfields we must say a few words concerning the dangers to which this delicate plant is exposed during the various stages of its growth and preparation. When young and small, it is, like other crops, liable to be drowned by too much rain; or if, on the other hand, the weather be too dry, its growth will be stunted. When full grown, a storm often injures or even destroys it in a couple of hours. A whole field of straw on the eve of being uprooted will sometimes be laid down flat on the ground, and the fragile stems will be crushed, stained, and unfitted for use. Even if only slightly bent, the ends will turn upward again, and continue growing, and the little knot or joint which is then formed in the stalk renders it almost unmarketable. If the weather is only foggy or damp, the straw is exposed to rust stains; indeed it is at all times liable to these stains if not properly dried. A great deal of wind will dry and shrivel it up, and harden it; it will also harden the ground and make it impossible to uproot the straw without spoiling it, while it will lose its flexibility and be unfit for plaiting if the grain forms itself in the ear before it is uprooted. A shower of rain will often spoil it after it has been uprooted and laid out to dry. It will be watched day and night if the weather is doubtful, and at the least approach of danger it is quickly piled up and covered with mats, or else taken under shelter. If not properly dry, it must not be kept too long piled up, or it will ferment. A great deal is often lost in that way, for as it cannot be laid out again in the wet and muddy fields, it will be spoiled, unless there are paved or gravelled places to spread it out in. When perfectly dry, its greatest dangers are over, for although watching is equally necessary during the bleaching process, changes in the weather occur less frequently and less suddenly in the more advanced season, and with a little care it is easily protected from any serious damage.

The next proceeding is the *sfilatura*, as the process of carefully drawing out each single straw from its outer covering or sheath is called. This is done by peasant girls who assemble for the purpose, and holding the sheaf firmly by the roots with one hand, they briskly pull out the straws one by one with the other, the straw thus deprived of its outward sheaf being tied in little bundles, weighed, and put aside for plaiting.

Before it is plaited, it must, however, be first properly sorted according to the different degrees of its thickness. This is usually done by machinery, the straw being ingeniously shaken in an upright position over a frame in which exceedingly small holes are bored, through which the very finest straws alone can pass. What cannot get through is taken on to a second frame with slightly larger holes, then to a third, and so on through 10 different degrees of thickness. What remains is set aside for very coarse hats and other uses.

The little bundles being now properly sorted and numbered, according to the size of the straw, the heads or ears are cut off, and the stalks are cut across in the middle to separate the top ends from the bottom, or *pedali*, the former being used for the finest plaits, the latter for the more common ones. The bundles are then wetted, and arranged in circular rows one above the other in an earthen or wooden tub or other receptacle; and a small vessel containing lighted sulphur being placed in the middle, the whole is well covered to prevent the fumes escaping, and the straw is well fumigated till it attains the proper degree of whiteness; it is then exposed to the sun until perfectly dry, and is ready for plaiting. If a part of the straw gets stained in course of preparation, it is dyed and used for mixed plaits or for coloured hats.

Nearly all the peasants plait. Some make their whole living by it, others only plait in their leisure hours, while tending cattle, or during the long winter evenings. In some places men, women, and children all plait, and little else is done. Straw merchants go about once a week in their carts from house to house, calling for the ready-made plaits, and leaving more bundles of straw to be worked. The plaits are made of different sizes and patterns, the usual plain ones being made with 7 or 11 straws, according to the width desired. An open pattern can be made by plaiting in a whalebone, which is afterwards drawn out, or the straw may be wound round a stick while plaiting, which when removed leaves a kind of curled edge on one or both sides of the plait. The plaits, if not found sufficiently white, can be again bleached and fumigated with sulphur before they are sewn into hats or bonnets ready for wear.

Straw can be sold at different periods. It is sometimes bought "on the ground"—that is, before it is uprooted—in which case a sum is fixed upon for the whole field, and the risks and costs of uprooting, drying, etc., rest with the buyer. It is more generally sold after it has been dried and taken home, and just before it is bleached, and then so much is given for each hundred sheaves, or *menate*; if sold after the *sfilatura*, that is, when cleaned and tied in bundles, it is sold by weight. The price varies according to the demand there is for it, and according to the quality of the straw. It has varied from 2 to 8 or 9 francs the 100 sheaves, so that it is impossible to give an idea of what can be gained or lost by straw raising. Machinery has lately been used for working straw, and a very pretty tissue is made of it, and used for making baskets, parasols, and other things; very pretty fanciful braids, fringes and tassels for trimmings are also made. The rich plait used for hats continues, however, to be made entirely by hand. ('Jour. Ap. Sci.')

There are three varieties of wheat of the golden plant (*pianta della fila d'oro*), as straw is called in Tuscany; the first is called *pontederas semone*, which produces the best straw for hats; the second, *marzuolo*, which is of a rather common quality; and the *santa fioro*, which is only used for pedals and braids. The *pontederas semone* is sown in arid soil, while the other two varieties require a more fertile soil. Seed is sown in November and December, according to the season, the object being to have the grain well up before the heavy frosts come, in the proportion of 11 hectolitres to each hectare, that is, about 12½ bushels to the acre. It is sown as thickly as possible, in order that the growth of the plant may be so impoverished as to produce a thin stalk, at the same time having towards the end from the last knot the lightest and longest straw. Side hills, with a gravelly soil, and high meadow lands that have had a surface ploughing and rough harrowing, are specially adapted to the straw culture, low swampy grounds being generally avoided, as dampness when the stalk is well grown renders the straw discoloured and coarse. The ground is ploughed and dug up in June, and left in this condition until November, when the soil is again turned up, and then it is ready for sowing. If the soil is very poor and thin, a very light surface of manuring is occasionally used, but this is not frequently resorted to, as it is apt to render the stalk thin and brittle. The wheat blooms at the end of May or beginning of June; it is generally pulled out by hand by the roots when the grain is half developed. For uprooting the straw, fine continued sunny weather is selected, as the rain has a very injurious effect upon it, often turning it black. When uprooted, the branches are tied together in sheaves, each sheaf or *menata* is spread out in the shape of a fan to dry in the sun for 3–5 days, after which it is stowed away in barns. The harvest being over, and the fields being only in stubble, the straw is again spread out to catch the heavy summer dews, and to bleach in the sun for 4–5 days, but not the whole of the crop at the same time for fear of a sudden rain. Formerly the yellow colour of the straw was preferred, but now the extra white is more sought after. Before being ready to be made up into braids, hats, and ornaments, the straw has to be again bleached, fastened in small bundles, and classified. It is then cut close above the first joint from the top, and again tied up in small bundles containing about 60 stalks in each. These small sheaves are then submerged in clear water for 4 or 5 minutes, and as soon as they become partially dried, are submitted to the action of burnt sulphur (in the proportions of 1 lb. to 100 bundles of straw) for three or four nights, in rooms adapted for the purpose; during the day the doors of these rooms are left open. The classification of the straw is made according to length and colour, the ear or end of the stalk having been previously cut off; all the straw below the first knot is used simply for forage or bedding, as it is worthless for the purpose of making braids or hats.

The plaiting of straw in England was usually done after the Italian method.* This consists in first carefully sorting the straws to a like colour and thickness, then taking a fixed number, usually thirteen, and securing them together at one end. The straws are then divided into two portions, six straws being turned to the left side and seven to the right, so that the two lots are at right angles to one another. The outer, seventh, straw on the right is then turned down by finger and thumb and is brought under two straws, over two then under two, and there are then seven straws on the left and six on the right. The outer, seventh, straw on the left is now turned down and passed under two, over two and under two again, and so the plaiting is continued, alternately doubling and plaiting the outer seventh straw until used up. Another straw is then put in under the short end, in the middle of the plait, and by the crossing of the other straws over and under it the fastening becomes secure. Fig. 158 will give an idea of this plait, while Fig. 159 will afford an idea how the edges are joined together, the dotted line showing how far the edge folds of one piece are inserted into those of the other. The stout thread that is run through is thus quite invisible and the join can only be detected by a slightly increased thickness.

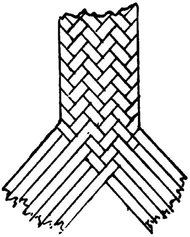

FIG. 158.

Plaiting is usually done in the spring, chiefly because the fingers are not so supple in winter, while in summer they are apt to soil the straw. The tarnish of fingers in summer, or smoke in winter cannot be cleaned off effectively.

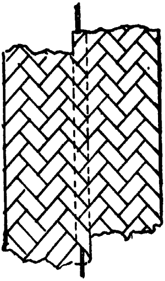

FIG. 159.

With straw grown in England; if fine work is required, the straw must be split. The whitest and most regular straws are selected, cut to equal lengths, then bleached (commonly in fumes of sulphur). They are now split lengthways into several pieces. This is done by means of a specially formed wire which is pushed up the straw, this wire having four, six or eight sides, the angular edges being sharp, so that they cut and divide the straw into four, six or eight strips. These strips are softened by soaking in water and can then be plaited. When sufficient plait is made it is pressed by being passed between wooden rollers which makes it hard and flat. In forming a hat of this material, a wooden block is provided and the plait is wound round upon this, each plait slightly over-lapping the other so that they can be sewn together. The whole work is afterwards pressed with a hot iron.

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* It may be stated here that this is practically a dead industry in England, the bulk of the straw plait used coming ready made from China.

Panama Hats.—These are made from the plant *Carludovica palmata*, whose leaves are 6–14 ft. high, and 4 ft. wide. In the Isthmus of Panama the plant is called *portorico* and *jipijapa*, but the last name is the most common, and is diffused all along the coast as far as Peru and Chili; while in Ecuador a whole district derives its name from it.

The *jipijapa* is common in Panama and Darien, especially in half shady places; but its geographical range is by no means confined to them. It is found all along the western shores of New Grenada and Ecuador; and it has been found even at Salango, where, however, it seems to reach its most southern limit, thus extending over 12 degrees of latitude from the tenth N to the second S. The Jipijapa, or Panama hats, are principally manufactured in Veraguas and Western Panama; not all, however, known in commerce by that name are plaited in the Isthmus; by far the greater proportion is made at Manta, Monte Christi, and other parts of Ecuador. The hats are worn almost in the whole American continent and the West Indies, and are greatly used in Europe. They are distinguished from all others by consisting only of a single piece, and by their lightness and flexibility. They may be rolled up and put into the pocket without injury. In the rainy season they are apt to get black, but by washing them with soap and water, besmearing them with lime juice or any other acid, and exposing them to the sun, their whiteness is easily restored.

The process of making these hats is as follows: The "straw," previous to plaiting, has to go through several processes. The leaves are gathered before they unfold, all their ribs and coarser veins are removed, and the rest, without being separated from the base of the leaf, is reduced to shreds. After having been put in the sun for a day, and tied into a knot, the straw is immersed in boiling water until it becomes white. It is then hung up in a shady place, and subsequently bleached for 2–3 days. The straw is now ready for use, and in this state is sent to different places, especially to Peru, where the Indians manufacture from it beautiful cigar cases, which have been sometimes sold in Europe for 6*l.* apiece. The plaiting of the hats is very troublesome. It commences at the crown, and finishes at the brim. They are made on a block, which is placed upon the knees, and requires to be constantly pressed with the breast. According to their quality, more or less time is occupied in their completion; the coarser ones may be finished in 2 or 3 days, the finest take as many months. The best times for plaiting are the morning hours and the rainy season, when the air is moist; in the middle of the day and in dry, clear weather, the straw is apt to break, which, when the hat is finished, is betrayed by knots, and much diminishes the value.

Dyeing Straw.—As a rule, straw goods should be well steeped, and then treated with alum, orchil, and indigo extract, and yellowed with turmeric. The shades most in demand are black, brown, and grey.

Black (for 25 hats): Logwood, 4 lb. 6 oz.; bruised galls, 17¼ oz.; turmeric or fustic, 4¼ oz. Boil for 2 hours, and then steep in a beck of black liquor (crude iron acetate) at 4° or 5° B. ; rinse in several waters, dry, and rub with a brush of dogs' grass, to bring up the polish.

Grey.—This shade can be obtained only on very white straws. Steep in a bath of soda crystals to which a little lime water has been added, to causticise the alkali. The purpose of this washing is to remove all traces of sulphur from the straw. For 25 hats, take: Alum, 4 lb. 6 oz. ; tartaric acid, 3½ oz. Add ammoniacal cochineal and indigo extract according to the shade desired. By making the one or the other of these wares predominate is obtained a reflection more bluish or reddish, a little sulphuric acid is added to the beck, to neutralise the alkalinity of the ammoniacal cochineal. The hats are boiled in the dye for about an hour, and rinsed in water slightly acidified.

Maroon (25 hats): Ground sanders, 1 lb. 10 oz. ; turmeric, ground, 2 lb. 3 oz. ; bruised galls, 7 oz. ; rasped logwood, 21¼ oz. Boil in a kettle so roomy that the hats may not be bruised. Rinse. Steep overnight in black liquor at 3° B., and rinse in several waters. To produce a deeper black, return to the first beck, which is strengthened by an addition of sanders and logwood. Polish as for black.

Havana.—This shade being a degradation of maroon, may be obtained by the same process, reducing the proportions by ½ or ⅓, and omitting steeping in black liquor. The hats may be soaked for a night before dyeing in 4½–6½ lb. of alum. ('Mon. de Teint.')

In order to obtain a level black colour, a solution of gluten is added to a lye of soda, which is allowed to stand for 24 hours, and filtered. The hats are then steeped for 12 hours in the clear liquid. The straw is thus freed from grease, and the mordants of nitrate, sulphate, or acetate of iron, as well as the decoction of logwood mixed with sumac or galls, is very evenly taken up by the fibre. A slight addition of potash bichromate improves the tone of the dye, and the goods are finished with gum or gelatine. ('Baden Gewerbezeit.')

Woven Matting.—*Russian Matting.*—Mats of lime (linden) bast form in Russia the object of a considerable trade. In the months of May and June, when the rising sap renders it easy to peel off the bark, the peasants go out to the forest for this purpose, with their wives and children. The lower part of the bark is usually employed for roofing, being first warmed and pressed so that it may not roll up ; they get in this way pieces 5 ft. long and 3½ ft. wide, costing 4*d.* each. The bark from the upper part of the stem and the branches is tied up in bundles, which are laid in water, where they are allowed to macerate till September.

They are afterwards dried in artificial heat, and divided into thin fine strips, which are woven into mats of different strengths, according to the various purposes for which they are to be used. They weigh 2–7 lb. each. The heaviest, and strongest, are sold at the market of Nischni-Novgorod.

Chinese Matting.—The United States Consul at Canton reports that the manufacture of matting is extensively carried on in China, especially towards the south, where it is one of the most important industries engaged in. Enormous quantities of matting are made both for export and home use, much being used as sails on the native sailing craft, as it is cheaper, if not more durable, than the ordinary canvas or sail-cloth. It is also used as coverings for boxes and packages in which tea, sugar, cassia, etc., are exported ; also in making money bags, it being a very convenient mode of handling dollars, especially when broken up into small pieces by the constant stamping or "chopping" of the dollars, as is the custom in China. The plant from which the mat sails, etc., so extensively used in China, is obtained, is known as "aquatic grass," also as "rush." It is cultivated in the Shuiling department on the West River, about 75 miles in the interior from

Canton. It is grown in the same way as rice, in fields flooded with water. It requires very little care in its cultivation, as it propagates itself by shoots from the root, and attains a height of 6–8 ft. It is brought to market in bundles of about 12 in. in diameter, and if of proper length and good quality, sells at about 10*d.* per bundle, each bundle being sufficient to make 4 bed mats, or 6 such as are used for making sails. The district of Tung Kuan produces large quantities of this grass, but of a species used almost entirely in the manufacture of floor matting. It is said to grow better in the vicinity of salt water, where the water flooding it is somewhat brackish. It is planted usually in the month of June from slips. These are allowed to grow for about 2 months, when they are replanted in rows. The soil being plentifully manured with bean cake, it requires nearly 12 months to mature, when it is cut, the shoots or straws are split with a knife, and, when partially dried in the sun, packed in bundles, and manufactured into matting at the city of Tung Kuan, or brought to Canton, where there are several extensive manufactories. When brought to the factory, the grass is carefully sorted, it is then made into bundles of 2–3 in. in diameter, and placed in large earthenware jars, holding about 10 gal. of water; it is allowed to remain thus in soak for 3 days, when it is taken out and dried in the sun for a day. If it is to be dyed in the ordinary red colour, which has been for years much in vogue, it is placed in jars containing a liquid dye, made by soaking red sapan-wood chips in water. It remains in these jars for 5 days, then dried for a day, afterwards again immersed in the dye for 3 days, when it is usually ready for use. It is only within the past 2 or 3 years that other colours, such as green, yellow, and blue, have been used to any extent. The solution for colouring yellow is produced from the seeds and flowers of a plant common to China, the *hui fa*. A yellow colouring matter is also made by boiling, for several hours, 25 lb. of the dried flower-buds of *Sophora Japonica* in 100 gal. of water, and adding, when cooled, 1 lb. alum to each 10 gal. of the solution. Green and blue are produced from the twigs and leaves of the *lamyip*, or blue plant, which grows in abundance near Canton. To the solution thus produced a small quantity of chemical dye is now usually added. In dyeing these colours, the straw is soaked in water for 7 days, and then immersed in the colouring matter for a few hours only, the solution being hot. Consul Lincoln states that in a recent visit to one of the largest manufactories, he found 50 looms being worked, 8 of which were large. The large ones are exactly the same as the ordinary silk loom, and are used in making the very wide, and also the damask or carpet patterns. The small loom is composed of 2 uprights, driven into the ground, about 5 ft. apart, and about 4 ft. in height, 2 cross-bars fitted into sockets in the uprights, one at the top, the other about 8 in. from the ground. The warps, which are strings of Chinese hemp, 2½ yd. in length, are then passed over the upper, and round beneath the lower cross-bar, through the holes in the weaving bar, and, being drawn taught, are fastened by both ends to a long, thin piece of bamboo, placed parallel with, and just below the lower cross-bar. The weaving bar, and the most important part of the loom, consists of a piece of wood, varying in length according to the width of the matting required, and about 2 in. square; through this, small holes are pierced at different intervals, into which the warps are passed; the bar can thus be worked up and down in the warps by means of handles near the extremities—these holes vary in distance from each other according to the pattern desired—alternately on top and bottom. The holes are enlarged, or formed into slots, converging at the centre of the stick. When the warps have been thus arranged, and bundles of different coloured straw, sufficiently damp, deposited near the loom, one of the boys raises the weaving bar to the top of the warps, tipping it forward, the slits in the bar allowing the alternate warps to remain perpendicular, the holes carrying the others forward, thus separating them sufficiently to admit of a single straw being passed between them. This is done by a long flat piece of bamboo, a notch being cut near the end, into which one end of the straw is placed, and then used as a shuttle. When the bamboo is withdrawn, the weaving bar descends, carrying the straw to the bottom; the bar is then raised again and tipped down, thus carrying the warps backward which had just before been passed forward, the work of the shuttle being repeated. As the weaving bar presses the straw down, the weaver gives the ends of the straw a half-turn round the outside warps, the operation being repeated until the warps are full, the edges trimmed, the warps untied, the matting now 2 yd. in length removed, and a new set of warps put on. The matting thus woven is then dried in the sun, and over a slow fire. The shrinkage consequent on this drying is nearly 4 yd. in 40. When dried it is stretched on a frame and worked down tight by hand, then sent to the packing-house, where men are engaged in fastening the 2 yd. lengths together, it requiring 20 lengths to make the ordinary roll. The fastening together is done by taking the projecting ends of the warps of one piece, and by means of a large bamboo needle, passing them backwards and forwards through the reeds of another piece, in fact, sewing them together; each roll of 40 yd. is then carefully covered with a coarse, plain, straw mat, marked and numbered ready for shipment.

The following remarks by Dr. Hance may be taken as supplementary to the above. The plant used for sails of native craft, or for covering boxes, and described in the United States Consul's report as an "aquatic grass" or "rush," is a cyperaceous plant, known to botanists as *Lepironia mucronata*. It is recorded as a native of the Indian Archipelago, Australia, and Madagascar. Of the matting made from this plant, Dr. Hance says the natural colour is a pale brown, nor is he aware that it is ever dyed, nor, so far as he knows, is it ever exported to foreign countries, except, doubtless, in the form of bed mats for Chinese residing in Australia and California. It is certainly remarkable that a plant of comparatively limited geographical distribution, and in none other apparently of its native localities turned to any account, should furnish the raw material for a vast manufacturing industry, and, perhaps, still more strange, that the source of this should not before have been discovered. As in the case of *Hydropyrum latifolium*, which supplies thousands of tons of a favourite vegetable, it shows how much we may have still to learn, even at the oldest and most frequented marts of trade, concerning the uses to which many apparently insignificant plants are put. The attention of the authorities in our possessions in the Straits of Malacca, and of those of Netherlands India might be advantageously directed to encouraging the cultivation of this plant, and so developing a large and profitable manufacture.

Regarding the floor matting, which forms such an important trade with America that it ranks in point of value about sixth or seventh of all articles shipped to foreign countries from Canton, the whole of this matting is woven from the culms of *Cyperus tegetiformis*. It does not seem to be known what the *hui-fa* plant is, from the flowers and seeds of which a yellow dye is prepared, but Dr. Hance is of opinion that the *lam-yip*, or blue plant, is referable to the natural order Acanthaceæ.

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STUFFING BOX PACKING.

THE question of selecting a thoroughly reliable stuffing box packing is undoubtedly one of the most important items in the management of steam plant. So many varieties of packing are now marketed that the problem becomes bewildering. As a matter of fact there are many establishments where the engineer in charge of the steam plant could not give off-hand his verdict as to which packing he finds most suitable. Others, again, will only have a packing composed of a hard or metallic substance, and again, there are those who prefer a soft, fibrous, or rubber mixture.

Modern steam practice has relegated to the category of the old fashioned, a host of packings composed of cotton, hemp, asbestos, soft metals, graphite, grease, etc., singly or in combination. Under certain circumstances, however, a number of these packings give fairly satisfactory results, but the aim of all packing experts has been to produce a material which would be equally efficient whether employed on steam, hydraulic or other plant.

The action of high steam pressure and superheated steam on the majority of soft packings results in these latter rapidly becoming hard and dry, in consequence of which it is practically impossible to keep the rod tight. In such cases the renewal of packings becomes not only a frequent and troublesome, but also an expensive operation.

Metallic packings have remedied a number of the deficiencies experienced with soft packing, but not all. This class of packing is generally all right until it requires tightening up, when, especially if the rod be worn, trouble invariably begins. Again, even when the packings referred to give fairly satisfactory results the rods must be kept lubricated from another source.

A later development is the Klinger packing (Fig. 160), in which the advantages of metallic and soft packing are combined, it being principally composed of a special packing material of a soft, fibrous, self-lubricative character, which in addition, possesses very high heat-resisting qualities; only a very thin cover is employed, and that solely to keep the other material together.

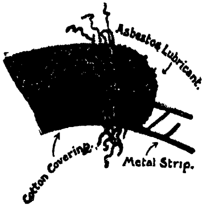

FIG. 160

The surface of the packing, which comes into contact with the rod, and which, naturally, is subjected to all the wear, is provided with a metal strip, having slit perforations, through which, when the stuffing box gland is properly adjusted, just that amount of packing needful for making a tight joint is pressed. This device is both novel and ingenious, and as a result, even with superheated steam, a perfectly reliable joint is obtained. The lubricative character of the packing reduces the wear and tear of the rod to a minimum. The expedition with which it can be placed in position is another of the features of this new packing.

Specimens of the new packing, which have been in service for a considerable period, show much less signs of deterioration than other packings which have done duty for only the same period. As a guide to the engineer, the packing is coloured red on that side on which is the slotted metallic strip previously referred to. The packing is square in section, and bulk for bulk—and this in the case of packing is an important point—is much lighter than many packings on the market.

The illustration shows how the

various constituents are arranged, and will demonstrate that the makers have given such attention to the subject of what really constitutes an efficient packing that they have discarded practically all previously held notions and have produced something at once original and unique.

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SUCTION-GAS PRODUCER:

THE WORKING PRINCIPLE OF.

THE first two pages devoted to this subject contain matter extracted from a series of Cantor lectures, delivered by Dugald Clerk, M.Inst.C.E., before the Royal Society of Arts.

The suction producer is already well established, and many hundreds of installations are now at work, and operating with great success. In the original Dowson pressure producer a fire is lit within a firebrick casing, and a mixture of air and steam is blown under the grate and into the fire by means of a steam jet from a steam boiler, the steam jet inducing an air current. The air and steam mixed pass through the anthracite and decompose the fuel; that is to say the steam is decomposed and the carbon combined with the oxygen of the water and the oxygen of the air, forming carbonic oxide gas, as represented by the formulæ—

$$C + O = CO \quad . \quad . \quad . \quad . \quad (1)$$

and $$C + H_2O = H_2 + CO \quad . \quad (2)$$

Steam cannot be decomposed without the addition of heat, but steam in the presence of red-hot carbon, or a little more than red-hot carbon, will decompose, and carbonic oxide and hydrogen are obtained, but this action absorbs heat. The combustion of the carbon as set out in the first equation gives out heat, which is utilised according to the second equation to break up the steam. The function of any producer, however, of the pressure or suction type is to utilise the heat from the combustion as much as possible so as to give, instead of the solid carbon in the anthracite, a mixture of gaseous fuel, carbonic oxide, and hydrogen, with diluting nitrogen, in order to give a fuel suitable for introduction into the gas engine or internal combustion cylinder. Theoretically, that transformation from the solid carbon by means of air and steam can be made without loss, but practically there is always some loss. If it were possible just to keep the furnace at the temperature at which all the heat that left the furnace would be taken up for heating the entering steam, it would be possible to get a reaction which would give a 100 per cent. of the heat in the form of cold gaseous fuel ready for the gas engine; but there is always a ratio of imperfection or inefficiency, and in the pressure producer the usual proportion of heat converted into gas ready for the engine is about 75 per cent. to 80 per cent.; that is, 100 heat units given from solid anthracite give 75 or 80 units in the form of carbonic oxide and hydrogen in the pressure plant; 75 per cent. to 80 per cent. is a better result than is obtained in most steam boilers; but in the suction gas plant even better results can be got. My colleague, Mr. Adam, made a test of a Dowson suction plant some month ago, with the object of finding out the exact number of heat units of the fuel converted into gas, which was ready for use in the engine, and he found, as the result of nearly a fortnight's testing, that every 100 heat units put into the suction producer at Dowson's Works gave out a matter of about 90 heat units, in the form of gas suitable for use in the engine. In the pressure producers a steam boiler or a blower has to be used, and water has to be evaporated to go in with the air, and to decompose the steam and air by means of incandescent fuel. In the suction producer all that is done away with. The producer is started by a small fan worked by hand for about ten minutes, the whole of the mass of anthracite becoming incandescent. Water is supplied continuously, and is evaporised and drawn in by the air passing through the producer. At the start the hand fan is blowing gas right through the apparatus, and to a cock near the gas engine to make sure that the engine is getting a proper gas supply. When the gas becomes rich enough, the fan is stopped, and the engine is started in any usual way, and then begins to draw gas through the producer in exactly the quantity required for its operation, no fans or blower being required. The mixture of steam and air sucked in through the producer gives carbonic oxide, hydrogen and a little light hydrocarbon. The gas formed, with nitrogen from the air, goes to the scrubber, where it passes through coke over which a constant stream of water is pumped. The gas passes through a little sawdust to take any final tar out before it reaches the engine. This arrangement is found to be exceedingly effective, and it is coming into use very largely all over the world, because it has a very high efficiency, and there is no danger attached to it. There is no danger of poisonous or inflammable gas. The gas in the producer is in the pipes, and always at a pressure a little below atmosphere, because it is being sucked into the engine by the motion of the engine itself, giving an extremely handy and simple producer in a form that anyone can work, however unskilled. The producer may be placed in comparatively confined spaces, and without any danger of gas poisoning, which was one of the dangers of pressure producers, and, consequently, all over the world these suction producers are coming into use. Taking the ordinary price of anthracite delivered —in the tests which Mr. Adam made it was 24*s*. a ton—and taking a National engine of 40 horse-power, the price works out for 1 horse-power hour at rather under one-ninth of a penny. That is an exceedingly economical result, which practically no steam engine with anything like the same dimensions can attain. Speaking now of the future, although many of these producers are working at the present time, yet the future development is likely to be enormous; the competition with coal gas will be very keen; and the competition with other kinds of power will also be very great.

A very great point about the suction producer, in addition to its being a motive power much cheaper than can be got with coal gas, is the possibility of its application in many other ways, and for many other purposes; for example, for ships and motor cars. There is a large field open to the engineer who can successfully apply suction producers on board ship. I may say, of course, that Mr. Dowson is the oldest of the producer inventors and producer manufacturers, and I have given his name the preference; but nearly all engineering firms who build engines now, build producers as well, so that we can have suction producers for practically any purpose.

The sizes of the suction producers in operation at present in Britain vary from about 5 horse, as the lowest, up to about 500 horse, as the highest. There are pressure producers also using anthracite which go up even as high as 3,000 horse, not in one unit, of course, but in several units. Without doubt the suction producer offers very serious rivalry indeed to coal gas, and to compete with it on equal terms; the ordinary coal gas would require to be delivered to the consumer at about 9*d*. per 1,000 cubic feet.

Many attempts have been made to utilise cheap bituminous fuel for producers, but so far the early commercial stage only has been reached. Commercial success here will come in the near future, owing to the great further reduction in the price of fuel for gas. In the present suction producers the fuel used is anthracite, and anthracite in London, and wherever there is much carriage, comes to about 24*s*. a ton. If one could use ordinary engine slack, which can be got at most places at 10*s*. or 12*s*. a ton, or even less, one would have a corresponding reduction in the cost of motive power, and instead of coming out at a ninth of a penny, the cost might run down to as low as a twentieth of a penny.* Messrs. Crossley have recently produced a bituminous producer which I have seen at work, and it was working very well indeed. It is rather larger and has more plant about it than an anthracite producer, but still the fuel is so cheap that no doubt it is worth a great effort to get something of that kind. Other attempts have been made, and I wish to distinguish between the two classes of those attempts. There is not much difficulty in making producer-gas for gas engines from bituminous fuel, if you are content to put up a large scrubbing plant such as is used with the Mond producers, and such as is used in a gas works; but people using steam boilers are accustomed to see a very large generation of power in a very small boiler space, and they do not look upon the large costly plants which are used in some places, although very useful, as solving this particular problem of getting a producer that will work just like a steam boiler with the ordinary fuel.

The Mond gas differs from ordinary producer gas in this: in addition to making the gas, the ammonia that is in the coal is saved. Many coals contain a proportion of nitrogen, and if these coals on being decomposed are not heated too highly, ammonia is formed and is not decomposed. To keep the temperature of the producer down sufficiently, the Mond practice is to flush the producer through with a very large volume of steam in addition to the air—much more steam than is wanted for the chemical decomposition. About 2½ tons of steam are used for every ton of fuel. The inflow of steam into the producer has two purposes; the one is that it keeps down the temperature and prevents the ammonia being lost; the other is that it prevents the formation of clinker, and the stopping-up of the producer. In this arrangement to get the ammonia out, it is necessary after scrubbing and getting the tar out of the gas to scrub the gas in great acid towers, making quite a gas works installation. This does not belong to the type with which I consider the producer should be concerned, that is, the type of producer which takes the place of a steam boiler, and does its work with no more complication than the boiler.

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* Scotch anthracite can be delivered at Glasgow at 15*s*. per ton, so that in Scotland power may be obtained at a cost of about $\frac{1}{15}$th of a penny per horsepower-hour.

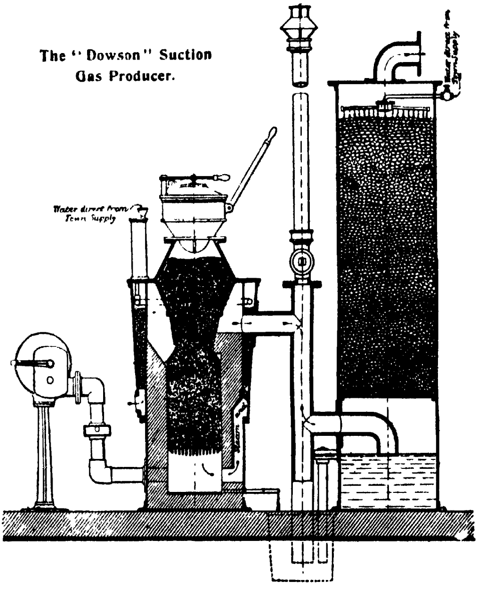

The "Dowson" Suction Gas Producer.
Water direct from Town Supply

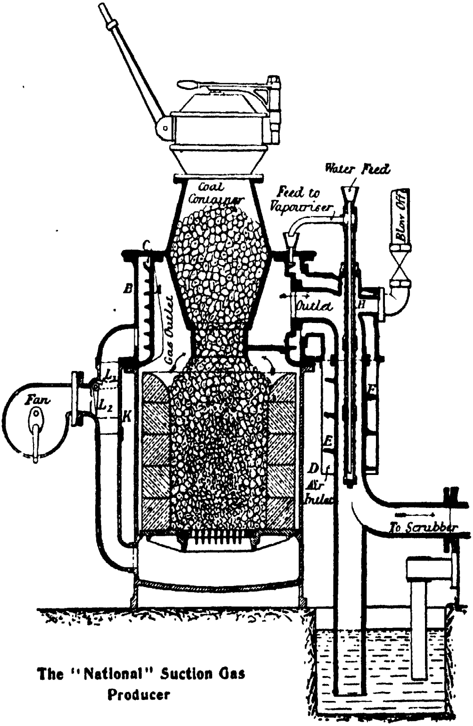
FIG 161.

To distribute the Mond gas, it is necessary to put it under some pressure, because the volume required is so very great. The calorific value is only about one-fourth or one-fifth that of ordinary coal-gas. The consequence is that to distribute this gas over large areas it is necessary to put it under very much heavier pressure than is used with coal-gas. The installation is therefore provided with a compressing house, intended to compress the gas for delivery in the mains. Mr. Humphrey states that a test was made recently at this establishment in which air was delivered along a main five miles long from these compressors at the rate of one and a-half million cub. ft. per hour. If that were pumping gas, this rate would be fully equal to about 15,000 horse per hour. This rate of delivery was attained with a pressure of 10 lb. per square inch at the central station, so that it is thought that ample pumping plant and ample pipe accommodation have been provided to take the enormous volumes of gas necessary in this system. It will be very interesting indeed when this installation starts. It is one of the largest and most important experiments in progress in the world, and all engineers look with interest upon it, and wish it every possible success.

The Royal Agricultural Society of England decided to offer, at its Derby show, 1906, a first prize (gold medal), and a second prize (silver medal), for suction-gas plants working under practical conditions with engines attached, and, needless to say, the trial was a very exhaustive one and based on the fairest possible conditions. The Dowson producer (of their latest design) did not succeed in gaining the first prize, but as stated in *The Gas and Oil Engine Record*, the producer (which is here illustrated in section, Fig. 161) responded to all degrees of load. The engine was exactly similar to that exhibited by the National Gas Engine Co., with the exception that the compression pressure was 15 lb. per sq. in. lower, being only 135 as compared with 150. The combination ran remarkably well, and there is little doubt that the performances, although not gaining an award, were excellent.

The producer that gained the gold medal was that made by the National Gas Engine Co. This is illustrated at Fig. 162. The producer, however, is entirely dissimilar from the Dowson generator, as may be seen from the accompanying illustration, and is unlike any other producer now upon the market in many ways. The generator, with its lining, fire-doors, and fuel valves have no uncommon features, but the methods employed for heating the air and generation of steam are very effective. Advantage is taken of the maximum temperature of the escaping gases from the fuel bed for raising steam before any radiation loss is possible, by arranging a steady stream of previously heated water to drip from a number of circumferential ribs, gradually increasing in width, cast round the exterior of the chamber enclosing the gas space above the fuel. There is no great absorption of heat by a large quantity of water commonly placed in a similar position, but the steam is quickly and effectively generated in any desired quantity by regulating the feed drip cock. The heat of the gases is again utilised outside the generator by placing concentric water tubes within the gas pipe. Cold water is fed to the inner tube to within a few inches of the bottom of enclosing tube. The water, becoming heated as it passes up the outer space between the inner tube and the gases, rises to a point sufficiently above the adjacent generator to cause it to be deposited at the uppermost portion of the spiral rib already referred to. The sensible heat of the gases is also utilised to heat the air supply by means of an outer jacket, the gas pipe being equipped with baffles to cause the air to come into intimate contact with hot surfaces of metal. In this highly-heated condition the air is able to absorb much more moisture than when at atmospheric temperatures, and it is straightway led into the vaporising chamber at the top of the generator, where it mixes with the steam and from which it is drawn by the suction of the engine through an external pipe connection to the space below the fire bars. In operation the external pipe is very sensibly hot, and this sufficiently demonstrates the efficacy of the steam-raising and air-heating devices. The amount of steam generated is always under the control of the attendant, and even under the severe test involved in the application of full load suddenly, after a two hours run "light," this producer was one of the few that responded without difficulty.

The "Crossley" plant succeeded in gaining the silver medal, this producer being illustrated at Fig. 163. This consists of a cylindrical firebrick-lined chamber, separated from the outside metal skin by a coating of sand. The firebrick lining rests on a metal ring supported on two cast-iron segmental-shaped boxes termed "superheaters," placed at the hottest part of the fire and mounted on a flat plate carried right across the producer. This plate has a hole in the centre in which rest the bars of the firegrate. In this way a pit is formed immediately below the firegrate, and in this pit the steam and air used in the gas-making process mix before passing together through the fire. On the top of the producer will be noticed a feeding hopper, through which the fuel is introduced. Around the cylindrical "bell," defining the depth of fuel in the producer, is formed the "well" of the saturator or boiler. Cold water is introduced into the bottom of this well and fills the rest of the saturator to a level defined by an overflow pipe. The saturator is shaped like a flat dish extending to the outside shell of the producer. This dish has a series of baffle plates on its under surface which form passages through which the hot gas has to pass, giving up its heat to the water before going to the coke-scrubbers to be cleaned. Two vertical



The "National" Suction Gas Producer

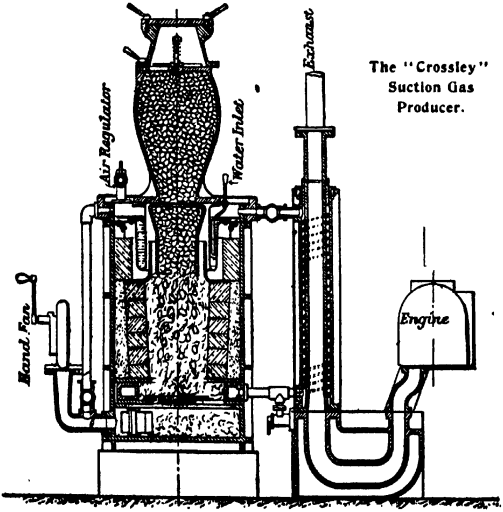
FIG. 162.

steam-pipes form the connection between the saturator and superheaters.

Producer gas is obtained by passing air and steam through incandescent fuel. Two simple reactions take place, expressed by :—

$$_2C + O_2 = {}_2CO$$
$$C + H_2O = CO + H_2$$

That is to say, the oxygen of the air combines with the carbon of the fuel to form carbon monoxide, and the steam together with more carbon forms more of the monoxide and free hydrogen. In addition to this, a certain amount of marsh gas, CH_4 and carbon dioxide, CO_2, are formed, so that the ultimate composition of the gas is—combustibles CO, H_2, and CH_4, diluted with the non-combustibles CO_2 and N_2.



The "Crossley" Suction Gas Producer.

FIG 163.

In the suction plant, here described, the requisite steam is raised in the saturator mentioned above by extracting the heat of the gas as it passes from the fire. All such plants to be economical must work on the "regenerative" principle. The older form of producer, in which even for small sizes a steam boiler was required, cooled the gas before sending it to the engine, by passing it through the atmospheric coolers, or, in other words, coal was first burned under a boiler to add heat that was finally wasted. The forward motion of the piston of the engine draws the air and steam through the producer. This does away with the necessity of a fan to force air through the fire, and has this further advantage that when the engine governor cuts out the charge no gas is made and no coal is burned in the producer. A great difficulty met with in designing suction gas plants was to obtain a uniform quality of gas with varying loads. When the engine governor cut out a number of charges steam continued to be raised; this filled the steam spaces, and the subsequent charge was exceedingly inflammable. It moreover cooled the fire in its production, with the result that after the temporary richness had passed off, the gas produced at a lower temperature was of poorer quality. This difficulty is got over by having one or more cocks opening from the air space above the water in the saturator into the open air. Through these openings the steam escapes at light loads. This is part of an important patent for the regulation of gas producers.

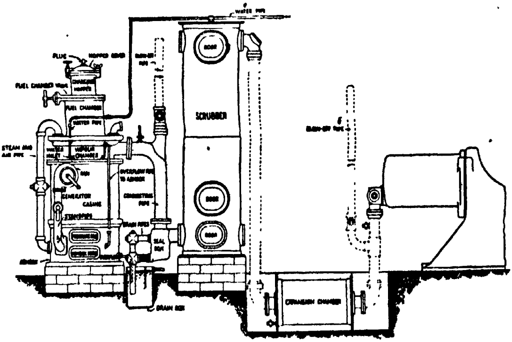


FIG. 164.

This producer has the grate with the pit below it. By this means any clinker forms in a flat cake over the grate and can readily be removed through the fire-doors. In addition to this, means are provided by which clinkers can be removed from the bottom of the fire-brick lining, should it form there, and the clinker immediately above the grate be broken up while the plant is at work. This ensures successful working, even with anthracite coal not of the best quality.

With anthracite at 21*s.* 4*d.* the cost of fuel per B.H.P. is one-tenth of a penny per hour. At full load on the engine the producer will not consume more than seven-eighths of a pound per B.H.P. per hour. A gas engine combined with dynamo running from a suction plant forms a very convenient set for electric light work. With such a combination the kilowatt can be obtained for very little over one pound of coal per hour.

In Fig. 163 the coke scrubber ordinarily used is not shown.

As already stated, the number of different producer plants on the market is already very large, many more than could be embraced in an article such as this, therefore a final descriptive example may be given in "Tangye's" producer, Fig. 164.

The method of working the producer plant is as follows :—

After lighting the fire on the fire bars, the generator is filled with fuel through the charging hopper, during which operation the small air fan is kept in motion until the fuel in the generator has become incandescent, which takes from fifteen to about twenty minutes (according to the size of the plant) starting from cold.

During this operation, the cock on the blow-off pipe is open, to allow the waste products to escape into the atmosphere.

The generator now being ready to supply gas, the engine is started in the usual manner, the suction "pull" from the engine causing the following action to take place :—

Air is drawn through the bend on the top of the vapour chamber, across the heated water in same, where it takes up, and becomes charged with, steam or vapour produced by the heat of the gases, etc., inside the generator.

The mixture of air and steam or vapour then passes down the air and steam pipe on its way to the bottom of the generator, and on, up through the fire bars and incandescent fuel, where it is decomposed; ultimately arriving at the outlet from the generator as a gas having a composition and heat value such as characterise what is generally known as producer gas (*gaz pauvre*).

The gas then passes by means of the connecting pipe to the coke scrubber, where it is cleaned and cooled, and so on to the expansion chamber, which serves to lessen the "pull" from the engine upon the flow of the air and steam through the incandescent fuel in the generator, and thus to produce an even quality of gas.

The vapour chamber is kept nearly full of water by means of supply and overflow pipes. The overflow is carried down and runs into the bottom of the generator, where it gives off additional steam or vapour produced by heat radiated from the hot fuel, and also from the hot ashes falling into the water. Any excess of water is carried away, by means of a pipe and bend, to a small bosh, and forms a seal.

The coke in the scrubber is kept moist and the gas cooled by running water through it—the waste water flowing through a self-sealing pipe into a bosh, from which it runs away to any convenient drain.

The lower end of the connecting pipe near where it is fixed to the coke scrubber, forms a regulating water-seal box, and is brought into use, for the purpose of preventing diffusion of the gases from the scrubber, when the plant is shut down.

All passages and pipes have a large sectional area, thereby reducing the resistance to the flow of the gases to a minimum, and ensuring high efficiency when working.

The coke scrubber should be of ample dimensions, a very important factor if inferior anthracite beans be used.

Fuels.—The most suitable fuel to be employed in the "Suction" gas-producer is Welsh anthracite beans, which is recommended on account of its cleanliness in use and freedom from tarry matter, and the generator is designed for the use of this fuel. There are, however, other fuels which may be utilised in the "Suction" gas plant if suitable arrangements be provided for dealing with the same.

Among these may be mentioned Scotch anthracite, which, although containing a larger proportion of ashes and tarry matter, and requiring a little more attention in working, are obtainable at very reasonable prices, and give results which are remarkable in their economy. The producer is well adapted for the use of this poorer quality fuel, and provision is made for separating the tar before the gas enters the cylinder of the engine.

Gas coke may be utilised as fuel with satisfactory results, but it must be of a well carbonised quality, washed and broken into pieces of about ½ in. to 1¼ in. diameter.

The "Suction" plant may also be modified to use wood charcoal. This material yields gas equal to that from Welsh anthracite. The charcoal must be in pieces like twigs (about ½ in. dia. and 2 in. to 3 in. long) thoroughly charred, so as to contain no tarry matter and free from dust.

When the plant is required for fuel other than best Welsh anthracite, this fact must be stated when enquiring or ordering, and full particulars of the fuel should be given, together with an analysis if possible, as in many cases it is necessary to modify the generator, and provide a special scrubber arrangement, etc.

Suction Producers for more than One Engine.—Occasionally some little trouble has been experienced in starting up more than one gas engine from a suction gas plant. Usually, however, it is due to a defective system of connecting pipes. In one instance, the plant was of 100 h. p. capacity. No. 1 engine was of 35 b. h. p. output, and drew its gas through an expansion box 18 in. diameter and 18 in. deep, connecting by means of 4-in. diameter pipe with a 6-in. T and 4-in. side branch. The No. 2 engine was 80 b. h. p. output, and drew its gas from an expansion box 24 in. diameter and 24 in. deep, connecting with the main 6-in. pipe. Either of the engines would start up easily, but when the second was tried the trouble began. The engine that was at full speed robbed the one that was just starting, and the gas between the expansion boxes first fed one and then allowed the other engine to have a nibble, with the consequence that both were starved and came to a standstill.

The only way to get the second engine to start up was to let the first pull round the second by means of a convenient main-shaft. When both had attained full speed the gas supply became more continuous, and served both engines without further trouble. In another installation a large engine is connected up close to a suction plant, and a second (smaller) engine is more than 50 yd. away. Here, again, some difficulty was experienced, but the provision of a light non-return valve at the junction of the smaller service pipe has prevented any further trouble. A successful arrangement of piping to serve two engines was carried out in another plant. In this instance No. 1 engine is one of 45 b. h.p. and No. 2 of 90 b. h. p. The first draws from an expansion chamber of 30 in. diameter and 60 in. long through a 3½-in branch pipe. The second engine draws from a second expansion chamber of 25 in. diameter and 60 in. long through a 6-in. diameter pipe. Another installation is successfully in operation where the second engine is many yards away from the first, and in this case a separate service pipe is taken direct from the scrubber.

Six of the foregoing illustrations and much of the matter are reproduced by permission of *The Gas and Oil Engine Record*, this journal dealing exhaustively with the subject.

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SULPHURIC ACID.

(*a*) THIS substance, also known as *oil of vitriol*, is very largely used for many purposes in the arts and manufactures. It is a highly corrosive substance, though not to lead or glass. It combines with many known materials to form sulphates such as alum, plaster of Paris, etc.

The production of sulphuric acid requires a considerable outlay in plant, besides the employment of skilled labour. Either sulphur is used in the form of commercial brimstone, or iron pyrites (sulphide of iron) may be employed, though in the latter case suitable kilns must be provided to burn them either as lump ore or as dust ore, whichever can be obtained easily or cheaply.

The true sulphuric acid is a dry substance in the form of beautiful white needles, and is then termed anhydrous sulphuric acid, or sulphuric anhydride, its formula being (SO_3). Its affinity for water is so great, and the action when the two meet in any volume so rapid, that a hissing like red hot iron plunged in water occurs. The sulphuric acid of commerce, or oil of vitriol, is the pure material with water, forming an oily liquid, the formula then being (SO_3H_2O). It boils at 620·5° F. (327° C.), and has a specific gravity of 1·84. It should be colourless, but the ordinary commercial quality is straw colour. A noticeable feature is its extraordinary affinity for water, absorbing water rapidly from the air, and even from wood, sugar, etc., in which the water may be supposed not to exist ready formed but only in its elements. It actually causes the elements of water to unite and then withdraws them, liberating the carbon. It is of great value in the laboratory as a desiccating agent for gases. If sulphuric acid is mixed with water, suddenly and in suitable quantity, the rise in temperature is so great as to bring the water to or very near boiling point. The corrosive action of this acid is so strong that a little left on almost any organic compound (not omitting the human body) carbonises or chars it. The liquid sulphuric acid will dissolve the dry (anhydrous) acid, forming "fuming" sulphuric acid.

The process of manufacture is briefly as follows: The sulphur or the pyrites is burned in suitably constructed furnaces, which produces sulphurous acid together with nitrogen and excess of air, the latter of which should be as small as possible, as too great an excess serves no good end. These vapours or gaseous products are caused to pass into a chamber made of or lined with lead (the joints being burned, not soldered). These chambers sometimes have a capacity of 100,000 cub. ft. On the way to this chamber the sulphurous acid is caused to take up a small volume of nitric peroxide (NO_2), nitrate of soda being used for this purpose, this being sometimes burned with the sulphur or pyrites. As these enter the lead chamber steam is admitted, and a reaction takes place between the sulphurous acid and the nitric peroxide, by which the latter is reduced to nitric oxide (NO), and the sulphurous acid is oxidised to sulphuric acid and unites with the watery vapour. The reaction may be expressed thus—$NO_2 + SO_2 + H_2O = H_2SO_4 + NO$. As soon as nitric oxide is formed it absorbs oxygen from whatever air is present and becomes nitric peroxide again, which immediately contributes its additional atom of oxygen to another portion of sulphurous acid, and so on, so that a small proportion of nitric peroxide oxidises an almost indefinite quantity of sulphurous acid, as it acts merely as a carrier of oxygen.

The liquid substance that condenses on the walls and floor of the chamber is sulphuric acid and is drawn off, but it is not strong enough. It is concentrated by evaporation until it has a specific gravity of 1·70. It is then put into a still made of glass or platinum, and boiled until it has its proper specific gravity of 1·84 and, when cool, is then ready to be filled into carboys for transport.

(*b*) The term Oil of Vitriol was doubtless obtained by the use of iron pyrites (sulphate of iron), which is commonly known as "green vitriol." A simple method of preparing a small quantity is to boil sulphur in nitric acid or in aqua-regia; the oxidation of the sulphur by this means will produce sulphuric acid. A process adapted at Nordhausen (Germany) for the production of commercial sulphuric acid, and which is generally distinguished as Nordhausen acid, is to distil pyrites in earthenware retorts, the vapour being caused to pass into a receiver containing a little ordinary sulphuric acid. This makes a brown, fuming oily acid of a little greater strength, its specific gravity being 1·9.

(*c*) When sulphur (brimstone) is used it is ignited and burnt in a conical oven of brickwork. Pyrites are roasted in arched furnaces. To provide the nitric peroxide required (as mentioned in *a*) nitrate of soda (or potash) is put with some sulphuric acid in a pot, known as the nitre pot, this being placed just above the burning sulphur. The proportions are above 2½ lb. of nitrate of soda with about 1½ lb. of sulphuric acid to each ½ cwt. of sulphur. The nitre in the pot is decomposed, producing fumes which pass along with the sulphuric acid.

(*d*) Sulphuric acid may be filtered through glass-wool (slag-wool) but as it is an oily liquid the wool must not be packed tight. Instead of filtering it may be found that leaving the acid at rest for a time will cause all the suspended matter to settle after which the clear might be syphoned out. A glass or lead syphon would be required, this being first filled with acid, then short arm gently lowered until just above the deposit.

(*e*) Sulphuric acid when kept in glass bottles should not be corked up, as the cork will be attacked and in time the acid will become black. Such acid is quite serviceable for purposes in which the colour (due to organic substance) does not matter, such as the charging of electric batteries, etc., but to keep the acid clear bottles should have glass stoppers, ground in.

(*f*) Tanks for sulphuric acid may have their outer structure of wood or iron, but they must be lined with lead. Such lining must either be in one piece or it may be of sheets joined with molten lead, or have the joints made by lead burning (the edges being fused by a blowpipe hydrogen flame). Solder will not stand. It is possible to make a stone tank of 2 in. of York-stone flags, the joints being made by sinking the edges of the stone into grooves cut to receive them, sheet rubber being put in the grooves as a jointing material. When in position the parts are tightened up by iron bands and tie bolts.

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SUN DIALS.

Horizontal Sun Dial.—(*a*) To set out a horizontal dial first draw two lines parallel to each other, as shown at A and B, Fig. 165, the distance apart to be just the thickness of the upright style or gnomen which stands here. The distance, i.e. the thickness of the style, will probably be about $\frac{1}{16}$ in. Next draw a line at right angles to these, right across the dial, this being called the 6 o'clock line, one end marking 6 A.M., the other 6 P.M. This line comes across the sloping foot of the style as shown. (It may be noted that the triangular style is here shown lying flat on the dial. It, of course, stands perfectly upright, and the reason for showing it flat will be explained directly). Then with A and B as centres, draw quadrants (quarters) of circles and divide each into ninety degrees. Now, assuming the dial to be for the latitude of London, lay a rule over B and draw the first line through $11\frac{2}{3}$ degrees, the second through $24\frac{1}{4}$, third $38\frac{1}{12}$, fourth $53\frac{1}{2}$, fifth $71\frac{1}{15}$. Do the other side the same. Extend the afternoon hour lines of 4 and 5 across the dial and these will make the morning hours; while the morning hours of 8 and 7 prolonged in the same way, will give similar evening hours.

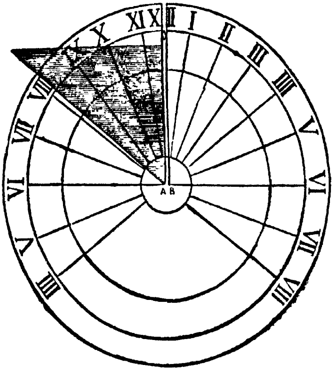

FIG. 165.

To form the style or gnomen draw a radial line through that degree of the quadrant which corresponds to the latitude (London = 51½°). This will show the elevation of the style. The method of doing this is shown in the illustration, the style being shown lying flat on the dial, its angle being 51½° with its base where it rests on the dial. When the style is made fix it perfectly upright between the lines A B.

The foregoing refers to a horizontal dial, but can be made to serve for a vertical dial, fixed facing due south, by making the style to an angle which is the complement of the latitude of the place; thus for London, which is 51½°, it would be 90° − 51½° = 38½°. In other words a horizontal dial prepared for London will be suited as a vertical dial (facing south) in any town or place at the latitude of 33½°, while a horizontal one prepared for 38½° latitude, will do as a vertical dial in the latitude of 51½°.

Dials for the south of the equator must be figured the reverse way to those set up for northern latitudes, i.e. the morning and afternoon hours changing sides.

A circular sun-dial may be regarded as a circle round the earth, or as the edge of a disc which passes through the centre of the earth from the spot where the dial is fixed. The letters *a*, *b*, *c*, *d*, *e*, *f*, *g*, etc. (Fig. 166) are longitudinal circles, representing the hours; B the spot where the dial is situated, D the corresponding latitude, P *p* the poles, and E the centre of the earth. A dial prepared for any particular latitude is useless for another latitude, except that a horizontal dial might be used for a vertical one for a latitude which is the complement of the first one as already explained. (F. T. Britten's 'Watch and Clockmaker's Handbook.')

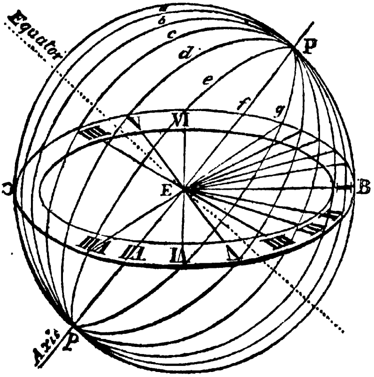

FIG. 166.

(*b*) Square dials are made by simply extending the hour lines that are set out as for a circular dial.

(*c*) The most satisfactory way to divide a sun dial is to calculate the angle that each hour-line makes with the XII o'clock line by, for a horizontal dial, the formulæ :—Tan. of hour-

TABLE I.—TABLE OF CHORDS AND CO-CHORDS OF HOUR-LINES OF HORIZONTAL SUN DIAL FOR EACH DEGREE OF LATITUDE FROM 50° TO 60° INCLUSIVE.

	11 a.m. and 1 p.m.		10 a.m. and 2 p.m.		9 a.m. and 3 p.m.		8 a.m. and 4 p.m.		7 a.m. and 5 p.m.	
Lat.	Chord.	Co-chord.	Chord.	Co-chord.	Chord.	Co-chord.	Chord.	Co-chord.	Chord.	Co-chord.
50°	·2021	1·2641	·4133	1·0912	·6421	·8853	·8923	·6347	1·1574	·3349
51	·2049	1·2619	·4186	1·0868	·6486	·8790	·8985	·6281	1·1610	·3305
52	·2077	1·2597	·4237	1·0825	·6550	·8729	·9044	·6218	1·1645	·3263
53	·2104	1·2576	·4287	1·0782	·6612	·8671	·9101	·6158	1·1678	·3223
54	·2131	1·2555	·4335	1·0741	·6672	·8614	·9155	·6099	1·1709	·3185
55	·2158	1·2535	·4382	1·0700	·6729	·8558	·9208	·6043	1·1740	·8148
56	·2182	1·2515	·4427	1·0661	·6784	·8505	·9257	·5990	1·1768	·3114
57	·2206	1·2496	·4471	1·0622	·6838	·8154	·9305	·5938	1·1795	·3080
58	·2230	1·2477	·4514	1·0585	·6890	·8405	·9351	·5889	1·1821	·3048
59	·2253	1·2459	·4555	1·0549	·6939	·8357	·9395	·5842	1·1846	·3018
60	·2275	1·2441	·4595	1·0514	·6986	·8311	·9437	·5796	1·1869	·2989

TABLE II.—TABLE OF CHORDS AND CO-CHORDS FOR ANGLES 50° TO 60°.

	Chord.	Co-chord.		Chord.	Co-chord.
50°	·8452	·6840	56°	·9389	·5847
51	·8610	·6676	57	·9543	·5680
52	·8767	·6511	58	·9696	·5513
53	·8924	·6346	59	·9848	·5345
54	·9080	·6180	60	1·0000	·5176
55	·9235	.6014			

('English Mechanic.')

line angle = tan. of sun's distance from meridian × sin. of latitude of place, and set out the angles so obtained by the use of chords and co-chords and a scale of equal parts. Table I. gives the chords and co-chords for the hour-lines of a horizontal dial for each degree of latitude from 50° to 60°. For intermediate positions take proportionate parts. For example, for the I o'clock line in latitude 54° 30′ the chord = ·2144 and co-chord = 1·2545. To set out the dial: draw two lines on the slab A O, *a o*, parallel to each other, and the width of the style apart, Fig. 167, and a third line *c o* O C at right angles to them. From O and *o* as centres with radius 1·000, describe arcs A B C and *a b c*. If the lines are correctly set out, the chords A C and *a c* should each measure 1·4142. From A and *a* as centres, with chord of I o'clock line as radius, describe arcs cutting the arcs A B C and *a b c* in B and *b*. From C and *c* as centres with co-chord of I o'clock line as radius, describe arcs which should exactly cut the previous intersections at B and *b*. Join B O and *b o*, which are the XI and I o'clock lines

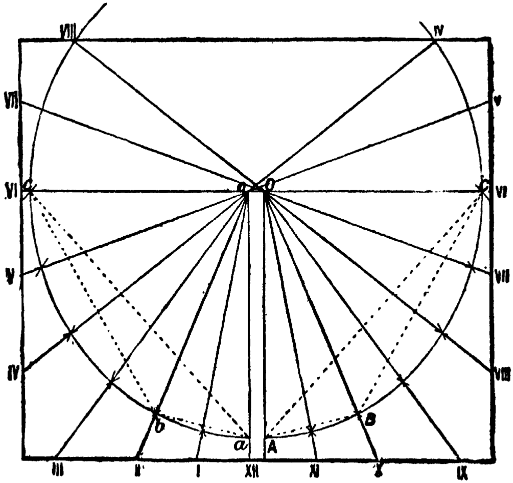

FIG. 167.

respectively. Proceed similarly with the other hour-lines. In the figure the setting-out of the X and II o'clock lines is shown. The V A.M. line is the V P.M. line produced, and it should be noted that it passes through *o* not O. Similarly with other lines beyond VI o'clock. The angle of the style can be set out with the scale of chords, and checked with the scale of co-chords given in Table II. For intermediate places between the degrees calculate proportionate chords and co-chords. For example, for latitude 53° 20′ the chord will be ·8976, and the co-chord ·6291. The edge of the style must be set so as to intersect the plane of the dial exactly in the line O *o*. Of course, the dial must be exactly horizontal, the style vertical, and the XII line set truly N. and S. Owing to the sun having a disc of a considerable area, the shadow of the style is not sharply defined and there is a tendency to read time by the dial fast in the forenoon and slow in the afternoon. For correcting a clock, therefore, a mean should be taken of a forenoon and afternoon observation, if an observation cannot be taken at XII.

* * *

TAXIDERMY.

(*See also* CLEANING AND SCOURING, *and* PRESERVING.)

Cleaning Stuffed Specimens. (*a*) Give a good brushing with a stiff clothes-brush. After this warm a quantity of new bran in a pan, taking care it does not burn, to prevent which quickly stir it. When warm, rub it well into the fur with your hand. Repeat this a few times, then rid the fur of the bran, and give it another sharp brushing until free from dust. (*b*) Sponge with white soap and warm water, rubbing well into and about the roots of the hair, but avoid using an excess of water to soak into the stuffing, or the specimen will, in all probability, never thoroughly dry, and moths and rot will be the result. Dry in a current of air as free from dust as possible; brush the fur occasionally as it dries (a coarse comb at first will, perhaps, separate the hairs better). Before putting it into its case, wash freely with benzoline, rubbing with the fur; you may never dread moths, and your specimen will always be clean if your case is properly made and closed up air-tight by means of paper pasted over every joint and crack.

Fish.—Cover the best side of the fish—the side to be exposed to view in the case—with muslin and place it on the bench. Cut along the side of the fish, from head to tail and remove the body. Carefully clean away all flesh that may be left around the fins and head, also remove the eyes. Now treat the inside of the skin, in every part with arsenical soap. For stuffing, the best plan is to make an artificial body with tow on wire, and, after being sure of the dimensions and proportions, putting this inside the skin and sewing it up. Another way is to gently ram in sawdust as the skin is being sewn up, but the fixing of the specimen in the case is not so easily done with this latter method. With the tow and wire body, two (or three) wires should be arranged to come out from the unexposed side of the body—so as to either pass through the back of the case or be bent down to pass behind some artificial water grass to the floor, these wires soundly supporting the fish in the air so to speak. After fastening the fish in the position it is to occupy, the fins and tail are arranged in the desired positions by means of pins and between pieces of cork. The eyes are finally inserted and the mouth closed. When it is quite dry the body is painted in the natural colours, using best tube colours with fine mastic varnish and turpentine, and then varnish to give the appearance of the specimen being wet. In painting considerable care is requisite, or the best work may be given a poor appearance. Every scale should be finished separately, for the examination of a newly caught fish will show that the scales are shaded, also that the head has shadings and possibly markings on it.

Birds.—When the collection of specimens is a special business, as with a naturalist, there are occasions when speed, particularly in skinning, is of considerable importance, and this particularly applies in hot climates where the day's collections must all be treated at the end of the same day. The following is a rapid method, and has the advantage of affording good results in the after-treatment when mounting, etc. Examine the bird, arrange to show its best side, then plug mouth and nostrils with cotton-wool. With a keen knife make a clean incision from the wing to the thigh. Draw out the upper wing joint. Cut the sinews at the farther end and clean off the flesh. Now loosen as much skin as possible from back and breast, then, firmly holding the collar-bone, draw the body gently out. Cut through the neck and work to the other wing, and freeing this as was done with the other wing, work the skin off down to the legs. Get the skin loose to the knee joints, cut through the sinews, and, pressing back the flesh disunite the bone at the knees. The skin is now worked off to the tail, and after removing the oil-glands the bone is cut through and the body is quite detached. The wings can now be given more attention, these being bared to the second joint and having all flesh removed. Arsenical soap is then painted in here, and a little cotton wool stuffed in. Now attend to the head, taking hold of the severed piece of the neck, drawing it out and loosening the skin right to the beak. Cut away all that is possible (but not the skull), and extract the brains. Use arsenical soap here and fill the brain cavity with fine tow. Apply arsenical soap to all parts, then insert a false body as described elsewhere, putting wings, legs, and feathers all in methodical order, then either winding thread round or putting the whole in a still paper cone or cylinder. For relaxing when setting up is to be proceeded with, a relaxing-box is used, this being a box lined with material that will hold a quantity of water. About 24 hours in this will make the specimen elastic enough to have its stitches removed, and the false body removed. The skin should then be filled with damp tow (damped with warm water) and put back into the box for about two days. See that some of the damp tow is filled into the neck and mouth. A solution of soft soap and glycerine (with water) painted on the inside of the skin and allowed to soak a time will give elasticity.

It should be noted in skinning birds with large skulls that the skin of the neck will not pass over them, and in this case one side of the head—of course the side or part that would not be seen—is opened to deal with the skull.

Arsenical Soap.—By weight, 64 parts white arsenic, 64 parts white soap, 10 parts camphor, 8 parts chalk, 4 parts salt of tartar. Powder all dry ingredients, then work well into the soap, using sufficient water for the purpose.

Birds. Setting up.—Assuming the skins have been made flexible as already described, the setting up may be proceeded with. The brain cavity is always filled full, and tow is best for this. If the space is small, the tow may be cut up. For around the head cotton wool is best, as, by means of a hooked-end needle, fine strands of this can be drawn into places more neatly than tow. The wing bones should have a thin string or fine wire to tie them together, so that they will be, and remain, the proper distance apart as in life. The upper leg bones can be wrapped round with tow and returned to place. Now take a wire of fair strength for the size of the bird and the full length of the body, head to tail, point both ends, then wrap over evenly with tow to about half the thickness of the body and secure the tow on it. Now take two leg wires of full length, and sharpen one end of each. Push the sharp end through the sole of the foot, up through the leg bone, working it with a twisting, boring movement to get it through, until it comes out at the top joint and well through it. Now take the body wire, which is wrapped with tow, and seeing that the tow wrapping is the proper thickness of the next at one end, push this end up the neck and let the pointed end of its wire go well into the skull; the other end of this wire is to go into the tail bones. See that the wire at each end goes right through the bone, and, if necessary, pull the ends of the wire to make all sound. The body now having a core to work to, let the leg wires go through this core and then have their ends firmly twisted so that the legs will support the bird in the chosen position. Skill is now required to pose the bird, for nothing now remains but to fill in the cavity around the body core with tow and sew it up. If the bird is to have its wings outstretched, or away from its body at all, then wing-wires must be adopted, securing these to the body core as the leg wires were done. The last thing is to insert and glue in the eyes, the lids being arranged very neatly with straight or bent needles. Finally, bind all over with thread and leave to set.

Curing Material for Bird Skins.—For fresh skins. Mix together 2 lb. soft soap and 5 lb. whiting in a quart of water. Boil until amalgamated, then add ¼ lb. chloride of lime. When cool mix in 2 oz. eucalyptus oil.

Preservative for Birds.—(*a*) It is seldom that the exterior parts—the feathers—of birds require any preservative treatment, but should they be infected with destructive insects and need such care, then an alcoholic solution of perchloride of mercury may be used, working the feathers about with a finely-pointed instrument—a needle—until the spirit has evaporated and then putting in a current of air to dry. The chemical should not be too strong in the solution, and this can be tested by dipping a dark-coloured feather in it to see if any residue appears when the feather is dry. (*b*) Have a sufficient quantity of benzoline, and put some lumps of naphthalene in it to dissolve as much as it will, work this in between the feathers. (*c*) To destroy destructive insects, put the specimen in an air-tight box or tin with some carbon bisulphide for about three days. (*d*) To keep insects out of the case in which a specimen is mounted, put a few lumps of naphthalene (albo-carbon or carbon ends) in the case, out of sight. The writer has done this for years and finds it highly successful for mounted entomological specimens as well as larger things.

Snakes.—A single wire, to extend from end to end of the specimen and bound with tow, suffices for this. Sharpen the end of the wire that is to come at the head end, then bind the wire with a little tow to quite cover it. Hang up the skin by the head, then insert the blunt end of the wire down to the tail end. Have some fine sawdust, and by means of a funnel fill this into the snake-skin around the wire. As required, work the sawdust down by patting and pressing with the hands outside the skin and by inserting a tow-headed wire or cane to act as a rammer. When the cut part of the skin is reached, a few stitches are put in and the filling continued, then more stitches and more filling until within 5 in. to 6 in. of the head. Now fill the brain cavity with tow, insert the pointed wire in the spinal cord opening of the skull, push it through, then draw the wire and bend it back to firmly secure it. Finish the packing and sewing, the last piece of packing being most conveniently done with tow. The body can now be bent and disposed in any natural form chosen, fine wire nails being used if necessary to hold it on a branch or similar position. Now insert the eyes, and leave the whole to dry. When this is done, the specimen requires finishing, this being the tightening up of loose scales with liquid cement (fish glue), and tinting with colours if this is to be done. Best tube colours should be used with turpentine and a little mastic varnish to prevent the colours drying too dead or flat.

Mounting Animals.—If it is possible, some thought should be given to the mounting when the skinning takes place, for, quite commonly, one side of the specimen is better than the other. In such a case, if only one side of the animal will be afterwards seen, then care should be taken to have all possible cuts in the skin on the invisible side. Thus in skinning the legs the two to come nearest to the observer should be opened on the inside, while the two farther ones may be cut on the outside. To make the mounting frame, cut a piece of stout wood (usually called batten) a little longer than will reach from the body joints of the fore and hind legs and bore four holes, two at each end, to receive the leg rods or irons. These holes should be bored obliquely. Another hole has also to be bored at each end for neck and tail irons. For the leg irons have iron rod of suitable strength for the size of the specimen (this instruction does not apply to anything larger than bears, leopards, small antelopes, etc.), one end of each rod being pointed, the other end being threaded and fitted with two nuts; the nutted ends are those that come at the feet of the specimen and go through and secure the specimen to the board that it is stood upon. Having arranged how the object is to stand, the various rods are bent accordingly and fixed in place. The next duty is to make the limbs of proper size—to model them as it is termed. The leg bones, if any, are secured to the leg rods by wire, then the substance of the leg is made up with a foundation of "wood wool" or wood fibre, binding it on with stout thread until the proper thickness is obtained. It is better to made limbs and parts of insufficient thickness rather than of too great a bulk, but an exact natural size should, of course, be obtained if possible. When the fibre is all bound on the limbs they are to be coated over with modelling clay to make them of even surface and smooth, and at the same time, by means of the clay, to show up any muscular development. With short-haired specimens, too, string or wire may be pressed on the clay to afford the appearance of veins where proper. The skin can now be put to the legs, if desired, and sewn on, more clay being inserted wherever found necessary. The head is the next consideration. The skull usually has a slot sawn in its base to receive a short piece of wood, this projecting from the hole about ½ in. A hole is bored through the length of this, that the neck rod may pass through and then be turned down at the end and secured by staples. The skull can be secured to the wood let in its base by fine wire nails. The skull has its exterior covered with wood fibre, bound on with thread, to make it of suitable size, and if there is any difficulty in binding this material on, a few thin nails may be driven on to fasten the threads on during the binding. Some modelling clay outside the fibre completes the skull ready to receive the skin. Having fixed neck, leg and tail rods firmly in the batten, bending the ends over and stapling them secure, the body can be proceeded with to complete the work. Fill up the neck, then the shoulders, then the middle of the body, with wood fibre, moulding the whole to shape by judicious pressing with the hand outside, and as the filling proceeds the sewing up may be done, a little at the time. If not already done, the specimen should be mounted on its board, and then the extremities (if claws), also the nose, mouth and eyes, must receive attention. For nose and mouth clay will be required to model them up, and should the lips be required to show any particular expression (as snarling), then fine pins may be inserted to hold the skin in position.

Mounting the larger antelopes, deer, horses, etc. For these a simple piece of wood batten for the body is scarcely sufficient, and it is usual to build up a wooden framework nearly the size of the body, covering this with wood fibre and afterwards clay, the fibre being bound on by stout thread passing over a number of headed pins or light nails driven at regular distances into the wood frame. To make the frame, piece together sufficient ⅝-in. or ¾-in. match-boarding that a full sized outline of the body of the specimen may be drawn on it, including the neck and the base of the skull, but not including the legs or tail, then with a bow saw cut through the pencilled outline after putting cross pieces to prevent the boards coming apart. This is shown in Fig. 168, which also shows two pieces of 2-in. to 3-in stuff secured crossways to the board just where the highest leg joints come, these being to receive the leg irons as shown. When the work has got as far as this, the framework should be mounted on a board (by means of the double-nutted ends of the leg irons), even if only temporarily so, for the subsequent proceedings require the body to be properly supported while being done. The framework now has additional battens attached to the centre board, and when there appears to be sufficient of these some thin narrow planking is nailed along, making the body as round or barrel-shaped as possible, but keeping within the bulk the finished body is to be, as the wood fibre and clay have to come outside this wooden body. The only reason for this wooden body is that, with one of the larger antelopes for instance, a good result, and, more particularly, a permanent result, could not be hoped for if the whole body consisted of little more than fibre packing. With this framework the skull can come direct on to the neck board, if slotted with a saw as explained in the last paragraph. The outside of the wooden body is finally covered with fibre, bound on, then coated with clay; and, where necessary, string or wire is partially embedded in to show up as veins. When the skin is on and being sewn up, any extra fullness required may be done either with more clay or with strands of tow. The tail, for instance, can be filled with tow. If it is a long tail, then a tail rod or wire has to be provided, this being bound with tow to a suitable size. It has always to be remembered that the skin of the

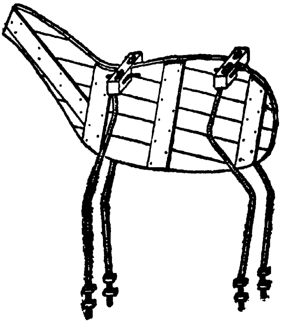

FIG. 168.

stomach may at first trial appear to be too large; this is because there are deep indentations of folds between the legs and body, in the groins, etc., skin having to be pressed up into these places and held there by fine nails or pins until set.

◆

TELEGRAPHY.

GENERAL PRINCIPLES, AND DOMESTIC WIRELESS TELEGRAPHY.

(*See also* ELECTRIC BATTERIES.)

THE most durable portion of a line of telegraph is the wire. In no instance, even with old lines, has rewiring been necessary, except by reason of some destructive agency. The kind most generally used for land lines is galvanised iron wire, and this is very suited for the purpose. It should, however, be of good quality, for it will take but very few faults or breakages to absorb the saving in first cost. The jointing is most important, the most approved method being that which is known as the Britannia joint. This is made by bending up the ends of the wire, then very firmly binding them together with a thin wire, and afterwards soldering over the whole. If the line wire is No. 8 B.W.G., then the binding wire should be No. 16. For thicker line wires the binding should be No. 14. A twisted joint is less strong than this one, and it is liable to cling to another wire if blown against it by the wind, and this has always to be guarded against. A very clean and smooth wire is also necessary to prevent this occurring. Whatever style of joint may be adopted it should always be soldered. They cannot be considered permanent without that precaution. Joints should always be kept near to the poles to prevent their being carried over and clinging to other wires when affected by strong winds.

The size of the wire is greatly governed by the length of the line, but apart from that, if first cost will admit, a large wire is at a great advantage over a small one. It will work under faulty conditions that would ruin the efficacy of a small wire. For circuits up to 400 miles No. 8 B.W.G. is very satisfactory. For shorter lines and for general railway purposes No. 10 will be found sufficient. For lines under 100 miles No. 11 may be employed.

The distance between poles or supports is determined by the conditions. Obviously the fewer the supports the better the insulation, and this means better and more economical results. After much discussion the number of poles has been fixed, for ordinary conditions, at 22 to the mile. The material used for poles is wood. Iron is very suitable, but the cost is prohibitive. These are always fitted with insulators, to prevent any leakage of the current or short-circuiting. The forms of these are various, but all rely upon porcelain or stoneware for their insulating properties. Fig. 170 represents an ordinary form of these, and Fig. 169 shows what is known as a double insulator. The efficacy of this latter pattern is not to be excelled.

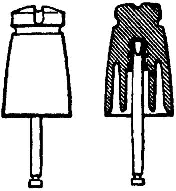

FIG. 169.

The connections to earth at each end of a line are effected by wires and copper plates. To effect a good earth connection—and many lines suffer greatly by want of it—the earth surrounding the plate should be permanently damp. Dryness of the earth is a great disadvantage, and in some rocky districts causes much trouble. When there are several circuits it is very necessary that the earth plates be kept as far apart as possible.

The ordinary form of indicating instrument with oscillating needle, still used by the majority of the railway companies, depends for its action on a current, passed through a coil of wire, which has a magnetic needle suspended on either side of it, causing the needle to deflect. As the current passes round the coil in one direction, so the needle is attracted to one side. By reversing the direction of the current the deflection of the needle is reversed also.

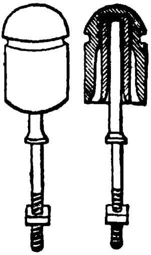

FIG. 170.

Figs. 171, 172 and 173 serve to illustrate this.

In the first illustration we have the contact-bar (which is worked by a handle) bearing over to the right, admitting of a current which causes the needle to deflect to the right also. In speaking of this deflection it refers to the upper half of the needle, the lower half being retained merely to balance the needle, and make it work freely on its delicate bearing. The direction of the current when the handle-bar is in this position is shown by the arrows, and it is requisite to explain that the centre stud or bearing of this bar is made of a non-conducting material, otherwise there would be a short circuit and no line current. The upper and lower half of the handle-bar are thus quite cut off from one another.

In the second illustration we have the current passing the reverse way to the last, it travelling to the distant station by the line and returning by the earth. In both these illustrations it is supposed we are sending messages from the instrument and not receiving any. When thus sending currents the battery of the sending station provides the motive power, and both movements of the handle-bar bring it into use. The deflection of the needle shown in these two illustrations are due to the current passing, for whether a message is being sent out or being received, the needle works the same. When sending messages the movement of the needle is very useful, first, to show that the current is passing properly, and secondly, it permits of the operator checking his own message as it goes. The former advantage is an important one, for except by the needle's movement an operator would never know if his message was going, and would frequently have to test the installation by other instruments. As it is, when his own needle moves it faithfully records what the needle at the distant station is doing. This is supposing no fault exists anywhere. If there is a fault the home needle usually gives indication of it.

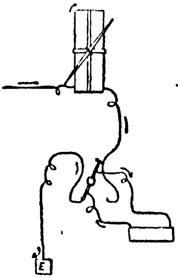

FIG. 171.

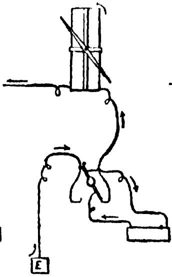

FIG. 172.

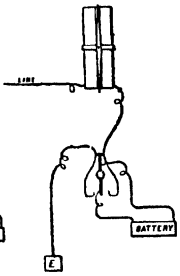

FIG. 173.

In the third illustration we have the instrument at rest, so far as the sending of messages is concerned, but it is in readiness to receive any that may be sent from the distant station. When messages are coming in, the battery of this, now the receiving instrument, is not required, as the sending battery only provides the current. In consequence of this a small tee or cross-head is provided to the handle-bar, touching in the manner shown, and so providing a bridge for the current from the needle-coil to the earth-plate, or vice versa. The current from the distant station therefore passes round the needle-coil, either way, freely and without hindrance, and, of course, the needle deflects accordingly.

Fig. 174 illustrates the face of the instrument-box with the needle only appearing, its coil and other fittings being in the body of the box (behind the face). The handle which operates the contact-bar is fixed in front, and the alphabet of deflections is usually printed on the face of the instrument somewhere. The alphabet signs are not difficult to learn, no letter having more than four deflections, and those letters most in use have one or two deflections only. The letter A, for example, has a deflection first to the left then one to the right. The letter N has the same deflections, but reversed as to order. E and T have one deflection only. Figures are denoted by five deflections each, as shown.

The form of instrument favoured by the postal authorities is that invented by Professor Morse. Originally it was made to leave a permanent record by printing its message in dots and dashes, and it is still greatly used in this way, but in busy offices the printing gear is often dispensed with, and the clicking or light rapping of the instrument is sufficient to the practised ear. This latter means of reading the message (by the ear) has caused modification of the instrument to be made, called "sounders," which rap out the message most distinctly, but these give no permanent record (except that which the clerk copies down), any more than the needle instrument does.

The action of this instrument is based upon the fact that if we take a bar of iron, and wind some insulated wire round it, we convert that bar into a magnet when a current is passed through the wire. The magnetic properties of the bar continue so long as the current passes, and cease or disappear when the current is stopped. This action is put to use in arranging the instrument, so that when a current is sent through the line the magnetised bar attracts and draws down one end of a balanced lever, this causing the other end to rise and come in contact with a strip of paper prepared to receive the impression of its contact. Immediately the current ceases the balanced lever assumes its original position, until the next current causes it to repeat its movement. This is the recording arrangement, and it is arranged that the recorded mark on the paper be either a dot, or a short line termed a dash. The dot is caused by a very brief current; the dash is the result of holding the transmitter down for an instant. The paper strip being kept in motion by clockwork, and the recording point being fed with ink, admits of these marks being registered very simply and distinctly. The alphabet of dots and dashes is arranged to resemble the symbols of the needle-instrument as near as possible, a dot answering for a needle deflection to the left, and a dash representing a deflection to the right.

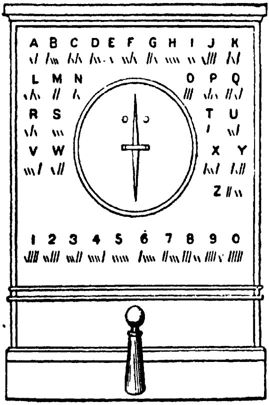

FIG. 174.

By this means a change of instruments does not necessitate an operator learning a new alphabet. To make this clear, Fig. 175 will show that the dots and dashes answer to the needle deflections, the letter S, for example, being represented by three dots, corresponding to three left-hand deflections of the needle alphabet for this letter.

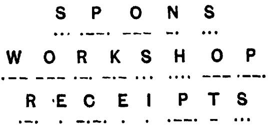

FIG. 175.

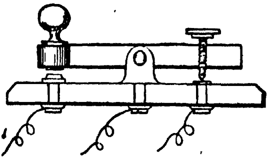

FIG. 176.

Fig. 176 shows the transmitting instrument, and Fig. 177 a complete circuit, upon this principle. In the latter illustration, A are the transmitting instruments, B the batteries, C the receiving instruments, D the galvanometers. As the transmitters are illustrated they are prepared for receiving messages, there being a free path for the current from the line-wire to pass to the receiving instrument and then to earth. If we press down the knob we cut off communication from the line-wire and permit the current from the battery to pass to it, and on to the distant station and the receiving instrument there, the current returning from the distant earth plate. The object of the galvanometer is to indicate that the message is passing. The needles of these fulfil the useful purpose that the needles of needle-instruments do, viz. indicate the transmission of the current. It might have been explained before that the needle and coil of this latter kind of instrument constitute a galvanometer, for a galvanometer is an instrument which acts by an electric current passing through a coil of insulated wire, and so causing a needle to deflect.

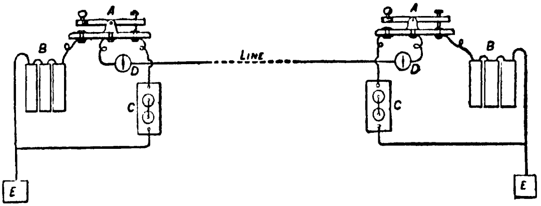

FIG. 177.

An interesting instrument connected with telegraphic and telephonic work is that known as the "relay." In all long lines it was found that, even with a sufficient battery-power each end, the current was not received at the distant station at a satisfactory strength, and this was particularly a fault with the Morse type of indicators. The aim and use of the "relay" is to afford what its name distinctly implies—like relays of horses on a long journey by road—fresh strength and impetus to the travelling medium. (*See* "RELAYS" in telephone work).

MORSE CODE.

A	- —	N	— -
B	— - - -	O	— — —
C	— - — -	P	- — — -
D	— - -	Q	— — - —
E	-	R	- — -
F	- - — -	S	- - -
G	— — -	T	—
H	- - - -	U	- - —
I	- -	V	- - - —
J	- — — —	W	- — —
K	— - —	X	— - - —
L	- — - -	Y	— - — —
M	— —	Z	— — - -

Domestic Wireless Telegraphy.—The first requisite is something that will make an electric spark. The coil of a motor-car or motor-bicycle will do admirably; an electrical machine such as the Wimshurt, or even an electric gaslighter at a pinch; or if none of these are obtainable then an electric bell, though the spark from this is too feeble to be of much good. If you look at it ringing in the dark, however, you will see that there is a spark. Now it is a fact, foreseen by Maxwell and observed by Hertz, that when a spark occurs a disturbance is produced in the ether and spreads outwards with great velocity in the same way that the waves spread when a stone is thrown into a pond. The man with the motor who aspires to use his ignition apparatus as a wireless transmitter had better disconnect his high-tension wire from his sparking plug, and connect some part of the engine with a piece of copper wire to the nearest gas-fitting or water tap. He will thus get a good earth—that is, there will be a way for the spark to run to earth. Two brass knobs of a bedstead should then be fixed so that they are about $\frac{1}{16}$ in. apart on two pieces of glass rod stuck into a wood base, and they should be arranged so that one knob is about $\frac{1}{8}$ in. from some part of the engine, and so that the other is about $\frac{1}{8}$ in. from the end of the high-tension wire. This arrangement will be more effective if the end of the high-tension wire is connected to one end of a copper wire about 10 ft. or so long, hung on silk threads so as not to touch any part of the room. This corresponds to the mast at the transmitting end of Marconi's system, and is called the aërial wire at the transmitting station. Now turn the engine until the trembler begins to buzz, and sparks will jump from the end of the high-tension wire on to the first knob; thence on to the second, and thence to the engine. Each time the current is switched on the disturbance will travel outwards from the motor, and the ordinary Morse code can be used; that is, the switch can be used as a Morse key for sending a series of long or short signals.

Now for the receiving apparatus. Get a bit of aluminium, either a saucepan or a comb, or something, and clean it carefully. Then get a bit of very fine copper wire, and thread it through the eye of a very fine needle. Twist the wire round some insulating support, such as a wooden penholder stuck upright in something, and arrange matters so that the needle-point just touches the aluminium. You have now made the simplest possible form of what is known as a "coherer." If you now join the aluminium to one terminal of a battery—one of the motor-car accumulators or a dry cell will do—and join the other terminal to the wire supporting the needle, you have a receiving station. The arrangement will be more sensitive if the aluminium is joined to a water-pipe or gas-fitting, and the wire supporting the needle is connected to a long copper wire, which is suspended on silk threads across the room, or the wire may hang out of the window, but so as not to touch the ground. This last wire is called the aërial wire at the receiving station.

There is still one thing lacking, namely, something to make the changes which go on in the receiver perceptible to our senses, but before this is described let us consider what we have now arranged—the circuit containing the battery and the simple coherer already described. What happens is this. The battery is always wanting to send a current down the needle to its point, and through the point to the aluminium plate, and so back to the other pole of the battery. It meets with no success in this endeavour, because the contact between the needle and the aluminium is very bad. However, when one of the disturbances sent out by the spark intercepts the aërial wire it sets up a disturbance in the wire itself, which has for its effect that the contact between the needle and the aluminium is much improved, and a considerable current at once begins to flow in the circuit. We want, therefore, something to enable us to appreciate this current. The simplest thing is a galvanometer, which need not be a very sensitive one, and this should be connected up somewhere in the circuit—for instance, between the battery and the wire supporting the needle—so that any current when it comes may flow through the galvanometer and deflect it. If no galvanometer is obtainable, a telephone receiver can be connected up instead of, and in the same way as, the galvanometer, and then the current when it arrives will produce a click in the telephone. The unfortunate thing is, however, that when once the contact between the needle and the aluminium has been made better by the influence of the spark, it remains better, and so the apparatus is no good for receiving a second signal until the contact has again been made bad. This can be done by tapping the aluminium with the finger very gently. If, therefore, our experimenter wishes really to transmit signals instead of merely satisfying himself that such a thing is possible—that is, if he is not content with an apparatus he has to tap between each signal—he must devise an automatic tapper. This can be a clockwork arrangement that is always tapping, but a much better way is to proceed as follows:—Instead of the galvanometer or the telephone insert in the circuit a small electro-magnet wound with fine wire, which will attract an armature when the current passes. The motion of this armature is utilised to close a second circuit containing a battery and an electric bell—that is, the armature, on being attracted, acts the part of the person pushing the button and rings the bell. Such an arrangement is known as a relay. The hammer of the bell not only hits the bell but taps the aluminium. Here, then, you have a complete apparatus, which signals on an electric bell. Starting with a bad contact between the aluminium and the needle, a spark is made in the motor-shed below. The contact becomes good, the current flows, the armature is attracted, the bell circuit is closed, the bell rings, the aluminium is tapped, and the contact gets bad again; the current ceases, and the bell circuit is opened and the bell stops.

If this receiving apparatus is fairly sensitive it will respond to the sparks from an electric gaslighter in the same room, but probably not from a greater distance. Ordinary substances like stone and bricks and earth do not materially stop the passage of the disturbance, but it is stopped by a metallic body which conducts electricity, and is partially reflected thereby. Thus the spark which occurs in the cylinder of a motor-car sets up no outside disturbance, as the cylinder walls are entirely opaque to it, and completely absorb the energy of the spark. With apparatus such as has been described it must not be expected that signals can be transmitted to any distance; but with a fair-sized induction coil, giving, say, a 4-in. spark, messages can be sent several hundred yards. In transmission to a greater distance much more powerful apparatus is required, and the aërial wires have to be made very long and the masts to carry them very high.

If our experimenter is possessed of a good induction coil it is worth while investing in a proper coherer and relay, neither of which is at all expensive. A coherer made of nickel and silver filings in an exhausted glass tube is worth about six shillings, and a very good relay may be purchased for about thirty shillings. It behoves the would-be purchaser, however, to remember that the possession and use of these occult pieces of apparatus is an offence against one of the most absurd Acts of Parliament ever passed—namely, the Wireless Telegraphy Act. ('E.R.C.,' in the 'Manchester Guardian.')

* * *

TELEPHONY.

Transmitters.—The microphone has been so named from its power of increasing sounds resulting from mechanical vibrations transmitted by solid substances, and thus rendering audible such ordinarily inaudible sounds as a fly's footsteps on the stand of the instrument. Its action is thus described by Prof. James Blyth.

Action.—In the microphone transmitter, as usually employed in circuit with a battery and a bell telephone, are essentially two pieces of carbon resting lightly against each other, through which the current passes. That the instrument may work effectively, two things are requisite: first, that the carbons be always in contact, or at least sufficiently near for the current to pass between them; and secondly, that they may not be pressed together so tightly as to prevent any motion of the one relatively to the other. This state of things is sufficiently well described by the term "loose contact." To understand the action of the microphone, it is necessary to find out what effects are taking place at the loose contact when the instrument is acted upon by sonorous waves. These are twofold: first, the effect produced by the sound waves (that is, the variations of density due to the condensations and rarefactions of the air), which pass directly through the air when they arrive at the loose contact; and secondly, the effect produced by tremors set up in the entire instrument, wooden supports, and carbons together, by the sound waves which strike against it and are thereby stopped.

For distinction, the first of these may be called the air effect, and the second the tremor effect. To isolate the air effect, it is obviously necessary either to fix the carbons rigidly in their supports, so as to avoid any motion of the one relatively to the other, or to use a strong current and place them just clear of contact with each other.

Fig. 178 illustrates how this may be done: *a*, *b*, *c* are three blocks of brass, firmly fixed to a heavy wooden sole-plate. To the top of *a* is soldered a piece of brass tube *h*, about 2 in. long and ⅜ in. bore. To the top of *b* is soldered a piece of similar tube *k*, about 4 in. long. Through *c* passes a fine screw *s* worked by a milled head *m*. A piece of carbon-rod *e* is fixed firmly into *h*, and has a hole ¼ in. diameter drilled through its centre. A long piece of carbon *f*, pointed at one end, passes tightly through the tube *k*, and can be moved backwards and forwords by the screw *s*. A piece of india-rubber tube *l* is passed over the left end of the tube *h*, and to this is attached a mouthpiece *n*. By means of the wires *x* and *y* soldered to the carbon rods, they are put in circuit with the battery *d* (20 Grove's cells) and the telephone *t*, which must either have a small resistance, or be placed in a separate circuit from that containing the battery, so as to be acted upon inductively.

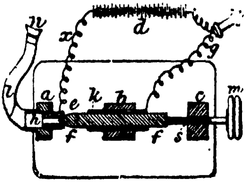

FIG. 178.

When the carbon *f* is screwed tightly into the hollow of *e*, the circuit is completely closed, and no sound uttered into *n* is heard at *t*. But when *f* is drawn gradually back until small electric arcs are seen to pass between *f* and *e*, every sound uttered into *n* is loudly and distinctly reproduced in the telephone *t*. Here is clearly only the air effect acting, and that solely upon the small electric arcs passing the carbons. It is somewhat difficult to get the sounds to last for any length of time, in consequence of the arc distance soon getting too great for the current to pass, and requiring re-adjustment. When the arc begins and ends, a sharp click is heard in the telephone ; but in the interval during which the arc lasts, the sounds are distinct.

As far as the tremor effect is concerned, it is obvious that the microphone action must depend either (1) upon the variation of resistance due to variation of pressure, or (2) to variation in the extent of surface contact due to the elastic yielding of the carbons under pressure.

To test the first of these causes, Prof. Blyth made experiments on the effect of pressure upon the specific resistance of carbon. For this purpose he took a short length of carbon rod, and soldered wires to it at a short distance from each end. By means of these wires the resistance of the carbon rod was balanced in the Wheatstone bridge. Pressure was then applied by means of a lever to the carbon in a longitudinal direction. No appreciable variation in the resistance was observed even under considerable pressure ; and it only became manifest when the pressure was sufficient to bend or crush the carbon. Similar experiments, with the same result, have been made by Prof. Thompson. Hence it can hardly be believed that variation of specific resistance due to pressure can have the slightest effect in producing the microphone action.

To test the second cause above mentioned—that is, the variation of resistance due to variation in the extent of surface contact due to elastic yielding under pressure—Prof. Blyth experimented as follows. In the apparatus already described, he replaced the tubular carbon by a finely-pointed piece, so as to have two fine points exactly opposite each other. The resistance of the points was balanced in the bridge in the usual way. Pressure was then applied by a known number of turns or parts of a turn of the fine screw, and the change of resistance was noted. The screw was then brought back to former position, and the pressure relieved so as to allow the elasticity of the carbon to act and restore the points to their first condition. It is obvious that if the change of resistance were due merely to elastic yielding, it should now be the same as before. This was found not to be the case. From the gritty nature of the carbon, the points of contact were perpetually changing, and hence the variation of resistance produced in this way obeyed no regular law. From this irregularity it is impossible to conclude that this cause could explain the transmission of musical sounds, far less articulate speech.

As far as Blyth's experiments go, the following appears to be something like the true explanation of the microphone action. What he has termed the air and the tremor effects take place simultaneously. The tremor effect produces a jolting of the carbons sufficient to allow momentary minute electric arcs to take place between the points which are just clear of contact with each other. Simultaneously with this, the air effect comes in, and on account of the variations of density due to the condensations and rarefactions of the air, acts upon the minute electric arcs so as to vary their resistance. The tremor effect explains merely production of the musical pitch of the sounds heard in the telephone, whereas it is to the air effect that we must look for the transmission of the quality of the sounds uttered into the microphone transmitter. The microphone is thus so far a delicate make and break analogous to the old Reiss transmitter, with the important addition, however, of minute momentary gaps filled with a material which is sensitive to the minute harmonic variations of the atmospheric density which constitute sonorous vibrations. (Prof. Blyth.)

Construction.—Instructions will now be given for the construction of microphones of various forms and patterns.

(1) Simple Microphone, capable of making the tramping of a fly, etc., audible (Fig. 179).—All the battery it

requires is a piece of carbon and zinc or copper and zinc, about 3 in. square, with a piece of blotting-paper between, damped with vinegar. It answers equally as well as an expensive battery. *f* is a box, size immaterial, say 4 in. square; over the top is stretched a piece of vegetable parchment; *a*, pieces of carbon filed to a knife-edge at top, to support small stick of carbon, *b*; *c*, piece of wood glued to *a* and to parchment top; *d*, wires connecting *a* with binding-screws *e*. An old sewing machine needle makes a good drill for drilling the holes into which the wires are wedged tight with the point of a pin. B is another form, scarcely so sensitive, but less liable to accident from flies walking over it. *a* are two pieces of carbon about ¼ in. square, fastened together by being glued to a thin piece of card which reaches about half-way up. The top of the carbon, in the centre, is cupped so as to hold a small pellet of carbon, ranging in size from a mustard-seed to a pea; *b*, wires to binding-screws. When all the connections are made, place a watch at the bottom of the box at *g*, and gently push the carbon piece *b* till it is almost falling over. A little practice will soon enable any one to get a very fine balance. The finer the balance, the better the result. When the ticking of the watch can be heard distinctly, take it out and place it on the top of box, resting the ring on the piece of wood *c*. With a moderately good telephone, the ticking will be sufficiently loud to be heard across a good-sized room. For flies, cover the top with a bell glass, or put them in the box and close up the opening. When using a common pin instead of *b*, flies may be heard running about almost as distinctly as with the carbon. A human hair drawn across the parchment is heard as a rustling sound in the telephone. The experiments should be conducted in a quiet room, as the slightest conversation or movement affects the microphone, and produces a jarring noise in the telephone. (T. Cuttriss).

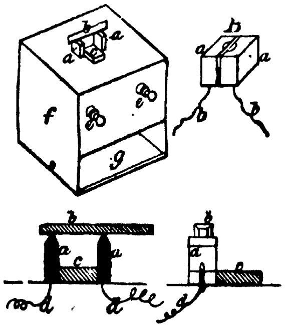

FIG. 179.

(2) Adjustable Microphone.—Get a piece of $\frac{1}{8}$-in. deal, about 4 in. × 3 in., polish it up, and ebonise it. Underneath put four corner pieces, two of which are shown at *h*, Fig. 180. Next fix one of the carbon pieces on the board. In one corner of the board cut a square hole through, as at *a*, then get your carbon block and bore a hole half-way through it, making the hole wider inside (*k*). The carbon block is sunk slightly into the hole at *a*, a piece of copper wire is inserted, and melted lead is poured into the hole, binding the carbon block on and making a good connection between it and the wire, which is then connected underneath to the binding screw at *b*. Then get a slip of thin "latten" brass about 2 in. long by $\frac{3}{16}$ in. broad, and punch two small holes in it, one at one end *c*, the other in the middle *d*. At the other end a piece of gas carbon, about ⅜ in. by ¼ in. by ¼ in., is fastened by means of melted lead. The end *c* is

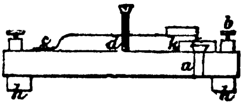

FIG. 180.

then fastened down with a screw and washer, the carbon end in this position being about ⅛ in. from the carbon block. A small spiral is made with No. 32 copper wire—this is put on a taper wood screw, which is screwed through *d* till the two carbon surfaces touch. If small sounds are intended to be shut out, the screw is tightened. It may, of course, be used with a soundboard if desired. ('Eng. Mech.')

(3) Gives excellent results in transmitting the human voice and musical notes (Fig. 181). The upright board has a circular hole *a* cut through it, about 2½ in. in diameter. Over this is gummed some vegetable parchment *b*, which, when the gum has well dried, is wetted and dried several times till quite taut. To the centre of this is fixed the upper carbon block *c* by means of a screw and a small wooden nut, and the wires are connected with battery and telephone in usual manner. I have only tried a 2½ in. hole, but am inclined to think that an improvement may be made by varying the size of the hole and the position of the carbon block on it. (T. J. Mercer.)

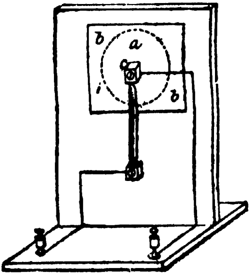

FIG. 181.

(4) Will transmit distinctly the loudest voice and the lowest whisper, when such are spoken 10 ft. or 12 ft. distant, without the smallest jar, and in the same tone as the speaker's voice. (Fig. 182). Take a piece of very thin deal, 5 in. by 2½ in., smoothly planed; fix to it the sides 1½ in. deep, equally thin; now add ends ⅛ in. thick. You will then have a lidless box whose bottom and sides are very thin and smooth, but with ends much thicker. Hold a stick of cask-wax in the flame of a spirit lamp, and run it in the seams where the sides and ends join—of course having previously glued them; screw this firmly through its end, to a stout base-board 3 in. by 7 in. In this box fix an ordinary microphone.; to the centre of the vibrator, cement a piece of iron wire. It is only necessary now to make a stand upon which to place a horse-shoe magnet; the stand, with the magnet upon it, must be in height so that when placed upon the base-board the feet of the magnet will stand parallel to the iron wire. The magnet may be fixed to the stand, but the stand must be free, so that it can be moved backwards or forwards on the base-board, nearer to or farther from the vibrator. Having connected your batteries and telephones, bring the feet of the magnet within ⅛ in. of the iron wire (the wire must not touch the magnet). Now speak, standing 3 or 4 ft. away—your friend will then report to you through the telephone the result; if not satisfactory, move the magnet farther away, until the voice is clearly heard, and in its natural tone. The results are equally as satisfactory as wonderful, the magnet merely acting as an easily adjustable spring in controlling superfluous vibration, which is the cause of that peculiar and annoying jarring sound. (R. Blakeborough.)

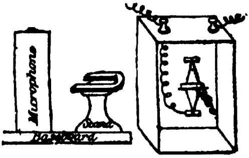

FIG. 182.

(5) Get a thin bit of board about 6 in. by 3 in., supported at each corner by little feet, also two small blocks of

carbon with a hole through the middle and a notch at the side of each; screw them into the board about $1\frac{1}{2}$ in. apart by binding-screws, and across them, resting in the notches, put a bar of carbon; it will much improve it if the carbon is heated red-hot and plunged into mercury. The microphone is now complete. To connect it, join one terminal of microphone with one pole of the battery and the other with one pole of the telephone; the second terminal of the telephone is joined with the other of the battery. (E. H. Hills.)

(6) The following arrangement of microphone transmits speech clearly. The sketches are sectional (Fig. 183). *a*, side of box; *b*, one of two pieces of copper between which the horizontal piece of pencil carbon *c* is spindled so that one end rests lightly on the other piece of pencil carbon *c*, which is fixed upright; *b*, the two pieces of copper mentioned before; *c*, end of the horizontal piece of carbon, under which a fine watch-spring *f* passes. One end of the spring *f* is screwed on to a wooden block *e*. The pressure of the spring *f* against the end of the carbon *c* is regulated by the screw *d*, which passes through it. Use a Bell's telephone as the receiving instrument. Speak in a low clear tone quite close to the microphone, and if the voice cannot be heard well at the other end of the line, tighten the screw *d*, thereby easing the pressure of the spring *f* against the carbon *c*. On the other hand, if too much vibration is heard, loosen *d* a little. Use either a small bichromate battery, or a single No. 2 Leclanché cell. ('Eng. Mech.')

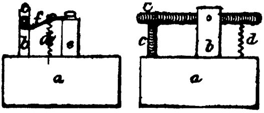

FIG. 183.

(7) Cup-and-ball Microphone (Fig. 184).—To construct the cup-and-ball microphone, take the case of an ordinary Bell telephone, remove the magnet and coil, cut off the long end or handle which contained the magnet, and plug up the hole in the case; turn the two cups out of a piece of a round carbon rod $\frac{3}{8}$ in. in diameter, and make the ball out of a piece of round carbon rod $\frac{3}{16}$ in. diameter. Secure one of the cups to the centre of the wooden case of the telephone by a small screw, and the other cup to the centre of the diaphragm of the telephone by a leaden rivet; place the carbon ball in the cup which is secured to the case, and place the diaphragm with the cup attached to it in its former position in the telephone case, having of course first carried a wire from each carbon cup to a terminal screw; see that the two cups are concentric; screw in the mouthpiece, and the microphone is complete. The microphone must be mounted in gimbals like a looking-glass, and slightly inclined backward or forward, until it speaks quite clearly, when it may be clamped. Each microphone has one position in which it speaks best, and this position must be found by actual trial. If the microphone is intended for ordinary use the diaphragm should be made of thin deal, straight-grained and about $\frac{1}{8}$ in. thick; after the carbon cup is attached, the wooden diaphragm should receive, in the side against which you speak, a coat of thin white hard varnish, put on in a dry room with a wide brush.

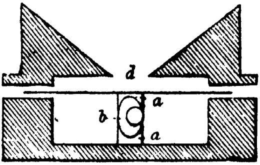

FIG. 184.

In the sketch, *a* are the carbon cups, *b* is the carbon pea, *d* is the diaphragm, and the shaded parts represent the telephone case, which, as drawn, is not closely screwed up. The open interior part of the case, i.e. the part which determines the area of the free vibrating portion of the diaphragm, should be 2¼ in. in diameter; the other dimensions may be varied according to fancy, but the carbon cup attached to the diaphragm should not be more than about ¾ in. in length. There is no difficulty in turning the carbon cups, the only tools required being a bradawl, which makes a capital drill for carbon; an old file to smooth down the back and face of the cup, which can, however, be done with emery-paper; the stump of any old small chisel ground to a long cutting slope; and a fret-saw. It is desirable to turn a small piece of box-wood to such a shape as will fit into the cup when completed, and by pushing this lightly into the cup whilst it is running in the lathe, the interior of the cup will be smoothed, and in many cases polished. To make the ball, chuck a piece of $\frac{3}{16}$ in. round carbon rod, and at the end turn a round head, like the head of a pawn in a set of chessmen; get it as nearly round as possible—a file is the best tool for this—and then cut it off; rub off any projections on emery-paper. The remainder of the process may be done in two ways. (1) Tack a sheet of emery-paper on a board, secure another piece of emery-paper to a conveniently-shaped piece of wood with a flat face; put the carbon pea on the emery-paper tacked on the board, and, with the other piece of emery-paper-covered wood, rub the pea about in every direction between the two, and with a little care the pea will become nearly a true sphere. (2) The other way, advised by Yeates, of King Street, Covent Garden, is—take a piece of sheet-steel about as thick as a screw-blade, and about 2 in. long by ¾ in. wide, soften it, chuck it by means of sealing-wax; drill a hole, about ⅛ in. in diameter, through the centre—the exact centre is not required; then with a *very keen-edged tool* enlarge this hole to about $\frac{5}{32}$ in. diameter, and take care that the edges of this hole are left sharp and not rounded; then harden the plate as hard as you can make it. Take the carbon pea which you have roughed down in the lathe, put it in the hole in the steel plate, rub it round in every direction between the finger and thumb, and after a while it will pass through the hole and be almost a true sphere. I have made the carbon balls by both these processes, and though the latter is by far the more accurate, the former has answered very well. One plate will make a great many balls. In all microphones, the points actually in contact, or which regulate the current, oxidize, and when this is complete, the current will not pass. In this cup-and-ball microphone, fresh surfaces are constantly coming into contact, and a shake will always ensure this. If the microphone is properly constructed, the ball should rattle loudly when the microphone is shaken. In screwing up the microphone, the diaphragm should not be pinched too tightly. The best way is to screw it up a little too tight, and then slacken it slightly. This microphone need not be round in shape; it can easily be made square, in which case the dimensions should not be less than 4 in. by 3 in., and a mouthpiece may be dispensed with. I have made a microphone with four sets of cups and balls, the diaphragm being about 7 in. in diameter, and the cups arranged with three pairs equidistant in a circle 3 in. in diameter, and the fourth pair in the centre; the cups in the diaphragm being connected together, and the cups on the back or case also connected; with this arrangement, a very strong battery may be used, when the articulation is a little louder, but scarcely so distinct as with one pair of cups only. If a multiple microphone is made up, the cups should not be less than 1½ in., nor more than 2 in. apart.

The receiver is made as follows:—Take a round piece of mahogany, or other dry wood, 2 in. in diameter and ½ in. thick; in the centre make a circular hole the size of a sixpence to take the electro-magnet: on one face mark a circle the size of a bronze penny; just outside this circle, and touching it, make three holes equidistant from one another, and the size of No. 9 B.W.G. iron wire; in each hole put a piece of this iron wire, long enough to project a little from the wood on each side; the electro-magnet is made of a piece of the same No. 9 B.W.G. iron wire, slightly less than $\frac{5}{8}$ in. long, and the reel is the size of a sixpence, $\frac{1}{2}$ in. long, and wound with No. 36 silk-covered copper wire; the electro-magnet is placed in the hole in the wood, the end of the wire is carried out to connect with the terminals, and the whole is boiled in paraffin. Two pieces of thin wood, about $\frac{3}{16}$ in. thick and 2 in. in diameter, are also required. In one a recess is made the size of a penny and rather less than $\frac{1}{16}$ in. deep; in the other a similar recess, but with a central aperture about $\frac{1}{2}$ in. in diameter, to permit the sound to escape; two discs of thin iron, 5 mil. thick, or ferrotype plate, are also required. Take the disc of wood containing the electro-magnet, the wires of which have, of course, been led to convenient terminals, file down the ends of the three iron wires on one side of the disc, until one of the thin iron discs, when laid upon these three iron wires, will *almost* touch the core of the magnet; let this plate remain on these three wires, put on the recessed disc of wood, which is without the central aperture, and secure it by three screws. The setting of the other thin iron plate requires more care, but is done in the same way, the projecting ends of the thin wires being filed down until the other thin iron plates, when placed upon them, and the whole put in circuit with an articulating microphone, speaks distinctly: the recessed disc of wood with the central aperture is then placed upon the iron plate, and secured by three screws, which must not be tightened too much, or the plate will not speak clearly. We have now an electro-magnet between two thin iron plates, which plates are in metallic connection with one another by the three iron wires; one plate being adjusted at the best speaking distance from the core of the magnet, and the other plate as near to the core of the magnet as it can go without touching it at any time.

The above directions will enable any one to make both the cup-and-ball microphone and the electro-magnet receivers; but remember that a good receiver is of no use with a bad transmitter, nor a good transmitter with a bad receiver. I have had these instruments in use for two years: they work admirably and give no trouble. For telephone work, I prefer the gravity Daniell battery to any other, but I intend to try the iron perchloride battery. (H. B. T. Strangways.)

(8) Fig. 185.—The diaphragm is constructed of white or yellow pine, four holders are glued to the sound-board, and, when dry, the pencils are put in place loosely by placing the remaining four holders. Connections of copper wire, cleaned well, about No. 30, are placed in the grooves in the carbon holders, twisted up, and a touch with soldering-iron afterwards makes all secure. On the opposite side of diaphragm is lightly glued a rubber-ring, about $2\frac{1}{2}$ in. in diameter, which rests when in box against the front, and the pressure is regulated by $\frac{1}{12}$ in. thick and 5 in. square; on the edges are glued two strips of wood *a*, about $\frac{3}{16}$ in. thick, shaped like a bridge, about $\frac{1}{2}$ in. at the middle and tapering gradually at the ends; these are glued across the grain, and prevent the sound-board *b* from twisting. The carbon pencils *c* are made from electric-light pencils No. 2, obtained from any electrical supply house, and the pencil-holders from No. 5 pencil. The pencils are 2 in. long, neatly filed to a point, and fitted into a small leaden tube *d*. The tube used for pneumatic bells answers well. Round the carbon is glued a leather collar *e*, which secures the lead in place, and acts as a damper in preventing the sound given by the carbon itself. This is heard if a small piece of carbon is struck, and is the cause of the metallic noise so often heard in microphones.

The length of the leaden tube should be $1\frac{3}{16}$ in.

The pencil-holders are cut about $\frac{7}{16}$ in. long, a hole is drilled half-way through, and a groove is cut round, as at *f*; a screw *g*, filed to a square, and moved by a key. This rubber-ring acts as a damper, and prevents noise and rattling.

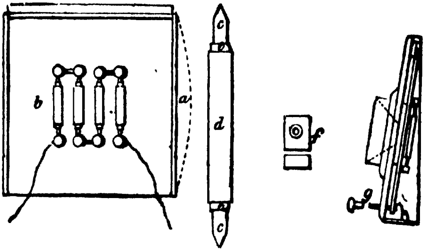

FIG. 185.

The sound-board is fastened to the inside of the box by a leather hinge glued along the upper edge; and on a slip of wood, the thickness of rubber-ring, a small spring presses at the lower edge of board, which keeps it close to the screw *g*.

The sound-hole in mouthpiece is 1 in. in diameter, and the box is made of well-seasoned mahogany, $\frac{1}{2}$ or $\frac{3}{4}$ in. thick, solidity being essential; the internal diameter of box is about $5\frac{1}{2}$ in., leaving a space of about $\frac{1}{2}$ in. all round the board, except at the upper edge, where the leather hinge is glued on.

When the adjusting screw allows the diaphragm to press lightly on front of box, the instrument is in order for speaking, and 8 to 10 in. distance gives first-rate results. The voice should be just as in ordinary conversation; music, such as violin, is beautifully heard through a telephone-receiver. Two or three Leclanché cells are sufficient for ordinary purposes. The microphone can be used well without induction-coil, and can be fixed to any of the existing arrangements with switch and bell. The angle of microphone box is 10° to 12°.

(9) Fig. 186.—The instrument consists essentially of two springs secured to a small base-piece, and each supporting at its upper end a piece of ordinary battery carbon. These two pieces of carbon are placed in light contact, and the two springs are placed in an electrical circuit in which there is also a receiving telephone of the Bell form. The instrument is represented secured to a small sounding-board. The two carbon-supporting springs are fastened to a single base by the binding-posts which receive the battery wires. An adjusting screw passes through one of the springs at or near its centre, and bears against a rubber button projecting from the other spring. This simple device, when placed on a table, indicates in the receiving telephone the slightest touch of the finger on the table or on

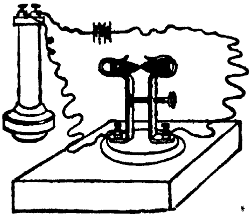

FIG. 186.

the instrument. Blowing on it makes in the receiving instrument a deafening roar; drawing a hair or a bit of cotton across the carbon is distinctly audible in the receiving instrument. When the device is placed on a small sounding-board, every sound in the room is received and transmitted. An ant running across the sounding-board can be plainly heard, and a touch upon the instrument or the table which supports it, which without the microphone would be entirely inaudible, can be distinctly heard in the receiving telephone by aid of the instrument, even though miles intervene. When it is placed on a violin, blowing lightly upon the strings produces æolian harp tones in the receiver, and a song sung to the violin is rendered in the receiving instrument with an æolian harp accompaniment. When mounted on a violin or sounding-board it will transmit articulate speech, uttered in any portion of a room of ordinary size; it will receive and transmit the music of a piano, and even the sounds of turning the sheets of music may be heard. Whistling, flute music and other sounds are transmitted with their characteristics of volume, pitch, and timbre. This instrument, although so very simple, is capable of doing all that has been done by other instruments of an analogous character, and it will be determined by further experiment whether it will do more. Although carbon contact points are preferable, they are not absolutely essential to the operation of the instrument, as metallic points will do the same things, but not so satisfactorily. (G. M. Hopkins.)

(10) Microphone for Reproducing Speech (Fig. 187). It consists of a box of thin wood, the front of which is perforated with a hole large enough to receive the tube of a common string telephone, the parchment membrane *d*, stretched over the inner end of which, is kept level with the surface of the board on the side at which the microphone is placed. The membrane *d* carries in its centre a small piece of metallised pine charcoal *c*, which is connected by the wire *g* and binding screw *k* to the battery wire. A vertical lever delicately pivoted on two points at *h*, carries at its upper end another piece of similar charcoal *p*, which is lightly pressed against the piece *c*. The lever is connected with the circuit by means of the wire and binding-screw *j*, and the pressure with which it bears on the charcoal, carried by the membrane *d*, is regulated by a light spring and silk thread actuated by the tension screw *t*. With a battery of six or seven Leclanché cells, words can be transmitted and received; but they are always much less accentuated than with the Bell telephone. The apparatus, however, appears to be a neat and handy form of microphone to employ for speaking purposes, and can be made very cheaply. (Th. du Moncel).

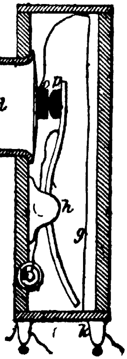

FIG. 187.

(11) Hughes's Microphone. — In order to hear the tramp of a fly, the microphone is constructed as in Fig. 188; *a*, stick of carbon (preferably the round compressed pencils used for electric light), pivoted on its brass support at *c*, and resting by the slight pressure of its weight upon a small block of metallised charcoal (blow-pipe box-wood, or any hard conducting charcoal will serve); the wires are

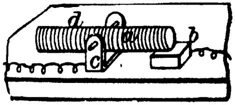

FIG. 188.

connected to the pivot support at *c*, and charcoal *b*. This structure is fastened to any small board *d* of pine, ⅛ in. thick, and 3 in. or 4 in. square. This will also perfectly transmit articulate speech if spoken to not closer than 1 ft.; if louder tones are desired put a small weight on *a*, and speak within a few inches of the microphone.

(12) Making Plates for Microphones.—The following process for making very thin plates for microphonic purposes is given by Trichasson, of Mourmelon-le-Grand. A sheet of ordinary tinned iron of any thickness is cut into plates, and rubbed vigorously on both faces with a dry linen cloth. This operation is to clean away all grease. A plate is then taken and plunged vertically in a bath of nitric acid until it is entirely immersed. Acid which has already served in Bunsen batteries will answer very well, or better still, the nitric acid of commerce, diluted with ¼ water. It is necessary to remove the plates from the bath from time to time, in order to see whether the required thickness has been reached. When this is attained, the plate is washed several times in water to remove the black layer of oxide. The plate is then allowed to dry, and afterwards varnished on both sides with Japan varnish to prevent oxidation. This process permits of making microphone and telephone diaphragms as thin as may be desired, and at little cost.

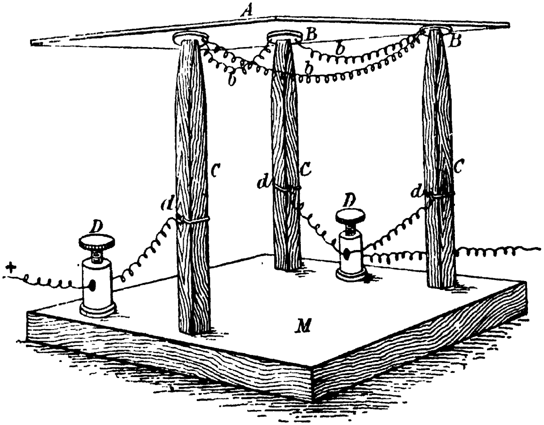

FIG. 189

(13) Fig. 189 is a microphone which any person who has the materials at hand can easily construct for himself. The vibrating plate A consists simply of a visiting-card of medium thickness cut square. Such a shape is much better than round, as the latter, although more elegant in appearance, does not give so good results. To this card are affixed by means of sealing-wax three thin and light discs of carbon B B B of the kind used for the electric light. These three discs occupy symmetrically the three apices of an equilateral triangle, and are put into communication by means of copper wires *b*.

With this object in view, a small aperture is formed in each disc, and into this is fixed the extremity of a copper wire either by cement or friction. The copper may be advantageously replaced by platinum. Finally the three wires are united.

The rest of the apparatus consists of a square wooden base M, which supports three prismatic carbon rods CCC, that exactly correspond to the three discs BBB. The two rods CC communicate by copper or platinum wires *dd* with the same terminal D. The third rod C communicates alone with a second terminal D. The upper extremity of these carbon rods must be chisel-shaped, such a form having been found to give the best results, inasmuch as the contacts become fewer in this case. The rods are fixed to the wooden base by means of sealing-wax.

The theory of this microphone is very simple. The current enters, for example, through the terminal D, follows the rod C and then the disc B. From the latter it passes through the wire *b*, into the disc BB, to return to the terminal D, in traversing the two rods CC.

This little instrument will prove very sensitive to the voice and all noises, provided that the plate A be given a proper weight, one that is neither too heavy nor too light. If this be done, the voice of a person speaking in an ordinary tone may be distinctly heard at the end of the room that contains the microphone. The sounds of a piano are particularly well rendered by it. The apparatus must be placed upon a table at a distance of two to three yards in order to protect it from the jarring of the earth.

Two or three Leclanché cells will be sufficient to operate the instrument.

The more modern form of transmitter used in telephone work is that due to Hunnings, the inventor, who originated the idea that by having two surfaces of conducting material placed opposite one another, and the intervening space filled with grains of carbon (about the size of fine gunpowder) a greater number of fine contact points would be made to respond to the vibrations, and the alterations to the current would be very great and pronounced. This proved to be so, and a remarkably efficient microphone transmitter was the result. The "Hunnings" transmitter in a simple form is illustrated at Fig. 190, this being a section of the instrument. C is a wooden or ebonite case with funnel-shaped mouth-piece (against which the voice is directed) at F. A circular diaphragm has its usual position at D, while at the back of the case is a thin disc of carbon, E. Between this back disc and the front diaphragm the space S is loosely filled with granular carbon. The line connections are taken from the back disc and from the front diaphragm as shown.

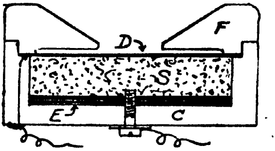

FIG. 190.

Fig. 191 illustrates another example known as the "Byng" microphone or transmitter. This illustration only shows the active parts in section, the case being omitted to make the description clear. In this there is the customary diaphragm marked D, while E is a moulded carbon back plate. These two parts are kept separate by a ring of non-conducting material at N. Another ring of similar material

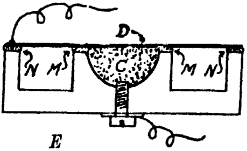

FIG. 191.

exists at M, but this usually consists of cotton wool. Cotton wool figures in many transmitters, as it acts as a damper or delicate cushion to the diaphragm, besides preventing contact between the front and back portions where necessary. The requisite contact occurs through the carbon grains enclosed in the cup-shaped space C, and this granular material gives the desirable effect of the Hunnings invention. Connection is made with the diaphragm and with the screw at the back of the instrument as shown.

One of the most complete and efficient forms of transmitters adopting the "Hunnings" system is the "Hunnings-cone Deckert." This resembles the last in having carbon electrodes, that is, a carbon diaphragm in front and a carbon back plate; and the space between the two accommodates the carbon grains. The peculiar feature of this instrument is the form or design given to the front surface of the back electrode. It is moulded with a surface consisting of a number of square conical projections or pyramids, and each pyramid has a small tuft of silk on its apex. These tufts of silk act as a damper, also as a non-conducting barrier between the two electrodes. They also serve the further useful purpose of preventing the carbon grains from shifting and clogging in a mass at one side of the space they occupy.*

The diaphragm is partially lined with a ring of cotton wool, the object being to confine the contact to the centre, where the vibration is most active. In the complete instrument, one connection is taken off the screw in the back electrode, but the other connection is taken off the case, which is in metallic contact with the diaphragm. There is no electrical contact between the back electrode and the case, as the ebonite back to the latter offers no opportunity for this. The metallic front part of the case, however, is secured tight against the edge of the diaphragm, so that a connection taken from the case is as good as one taken from the diaphragm itself. The front mouth-piece is the usual detail with all transmitters, that the voice, or as much of it as possible, may be concentrated and directed on to the centre of the diaphragm.

Induction Coils and their Uses.—Batteries providing a current direct from transmitting to receiving instrument are of little use for long-distance work; in fact, 100 yd. is quite the maximum distance that should be worked in this way, as such an excellent aid exists in the adoption of the Induction Coil. Even between a house and stables this adjunct may be necessary, and between house and lodge gates it is nearly always requisite. By means of the induction coil the distance between instruments can be calculated by miles, with practically the same battery power. In fact, where first cost is not all-important, it is as well to use the better forms of transmitters, like the Hunnings-cone Deckert, with induction coils, for residential work, in lieu of the cheaper instruments that are presently referred to.

The principle of an induction coil is that the current set up in an insulated wire by a battery can transfer, induce or set up a current in another insulated wire that is suitably associated with it; furthermore, that the current of the first wire can be increased in force (though weakened in quantity) when transferred to the second, and by this means it can travel further owing to its greater ability to overcome resistance. Fig. 192 will explain the method of associating the wires. M represents an electro-magnet, and on this is first wound a few turns of a moderately thick insulated wire. This is called the primary coil, and connected with it is the battery and the microphone transmitter. Around the primary coil comes the secondary coil of thin insulated wire, the number of turns this has greatly exceeding that of the primary coil. Connected with, or we should say a continuation of, this coil is the line wire or circuit having the receiving instruments on it. The finished coil nearly always has a cartridge-like appearance.

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* The grains are not packed in tight, only sufficient being put in to fill the space rather loosely.

With the battery connected as just explained, there will be a magnetic field created around the core within the coils which will generate currents in the secondary coil, reproducing the sound waves projected against the diaphragm of the microphone. Were it not that the word has a different electrical meaning, we might call this instrument a transformer, not that it transforms or alters the alternations in the primary current, but that it transforms a short-distance current into a long-distance one, and this without aid or special expenditure of battery power. Fig. 193 shows in simple diagrammatic form how the different connections come.*

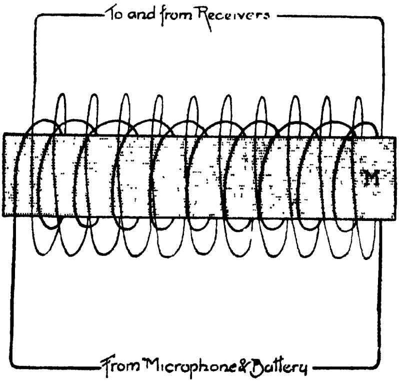

FIG. 192.

Circuits for Domestic Use in Residences, etc—There is no doubt about the utility of the telephone for domestic purposes, but hitherto the cost has been somewhat a bar to its adoption, and there has not been the simple form of instrument we now have, which can be inserted in existing electric bell circuits. The latter, of course, makes a great difference, as quite the major proportion of houses have the bell circuits already, and these are practically an inducement to having the telephone introduced.

The fixing is exceedingly simple, it not being even necessary to expose or cut the existing wires, so that in the case of bell wires being carried behind the plaster of walls immediately they leave the pushes, as is usually the case, there is no occasion to expose them and do injury to the decoration. The fixing is done by connecting the two terminals of the telephone with the two springs of the push, as Fig. 194.*

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* It would not do to connect up a circuit like this is done without further provisional details. As it is here shown the battery would soon become exhausted as no means are provided to stop the current when the apparatus is not in use. Neither is any ringing device shown. The diagram is given to explain the induction coil connections.

* This represents the "Household" telephone made by Gent and Co., Faraday Electrical Works, Leicester. This firm has kindly supplied most of the following diagrams of wiring.

The same method of connection is adopted when a circuit is newly erected, as can be understood by the diagram, Fig. 195. This shows how to connect three or any number of stations, to ring up and communicate with one station; but the latter cannot ring up either of the former. This is the method usually adopted in residence works, for, although the master of mistress may desire to ring up and converse to and fro with those in the servants' offices, it is rarely considered desirable to provide means for the servants to ring up their employers when they think proper. This may be wanted sometimes on business premises, and the wiring that is suitable will be found described later.

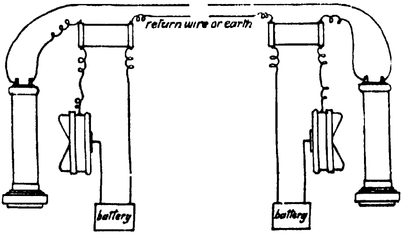


FIG. 193.

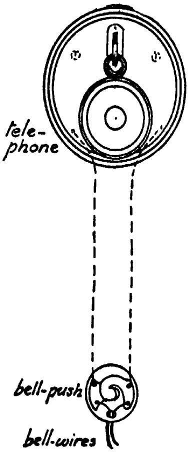


FIG. 194.

For the insertion of the "Household" telephone in an existing electric bell installation with indicator, the connections are equally simple, as will be seen by the diagram, Fig. 196. This illustration shows the extra wiring that is required in dotted lines. The four instruments in the rooms are the circular pattern illustrated at Fig. 194, while the one near the bell has a square back. This latter instrument is drawn small compared to the others, and is in correct proportion to the bell and indicator box, whilst the others, connected to the pushes, are shown larger.

Fig. 197 illustrates a later form of instrument which has been christened the "Transceiver," owing to its being a separate transmitter and receiver in the one instrument. This is made to be permanently attached to electric bell pushes, as with the preceding example; or it can be provided with the two-pin plug, here shown, which enables the user to carry it from room to room and use it anywhere that a push exists, provided with the necessary sockets.

For circuits outside the house the induction coil must form part of the sending instrument, and Fig. 198 illus

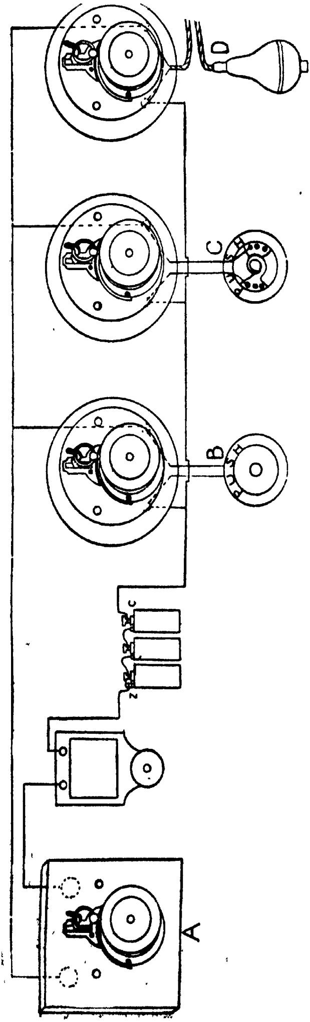


FIG. 195.

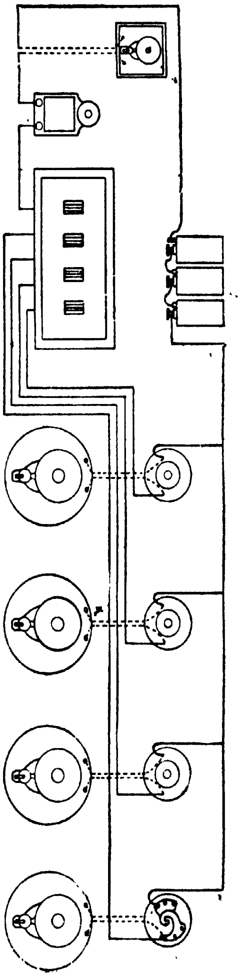


FIG. 196.

trates a complete transmitter with the coil complete. This illustration introduces another device, invented by Gent & Co., of Leicester, this being an arrangement which prevents the clogging of the carbon particles of the microphone. It is considered that all granular instruments are subject to a caking or clogging of the grains, as they are not disturbed in the fixed instruments, and this gradually reduces their sensitiveness. The plan of this instrument provides for a partial revolution of the microphone each time it is used, and this is automatically done, in fact, without the user knowing it. The instrument shown has the bell combined with it, and the whole is worked by a battery without a magneto-generator.

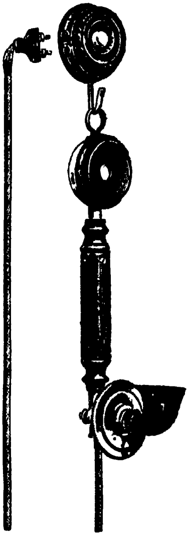


FIG. 197.

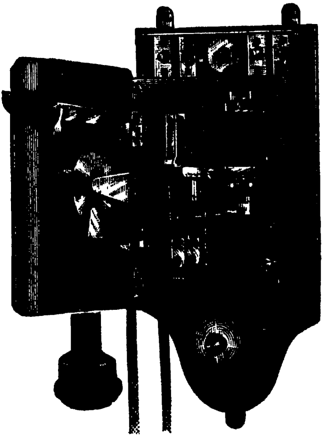


FIG. 198

Figs. 199, 200 and 201 are diagrams of wiring in which an induction coil figures. These are "battery-call" installations (no magneto-call being provided) and one battery only is required, fixed near the chief (Central) instrument). Fig. 199 shows a Central and four sub-stations, while Fig. 200 includes a Central and two sub-stations, one on each side. The principal of wiring is identical in each. A line is taken from each of the switch studs of Central to the first terminal of the corresponding sub-station. Another line is taken from the "home line" terminal of Central and branched to the second terminal of every sub-station. Two other lines are run from terminals 6 and 7 to the third and fourth terminals of every sub-station. The Inductor Coil being inserted in that leading to the fourth terminal.

Fig. 201 shows a set of instruments wired for inter-communication. The

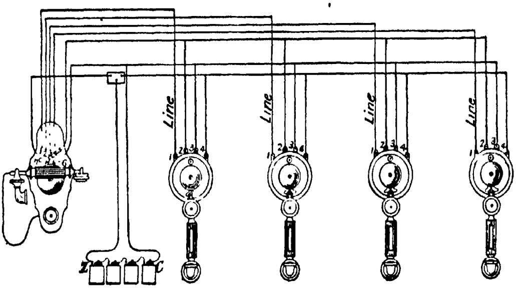


FIG. 199.

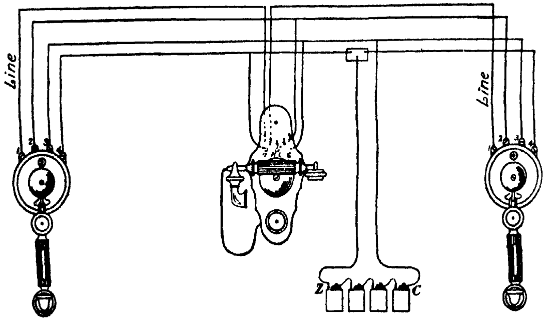


FIG. 200.

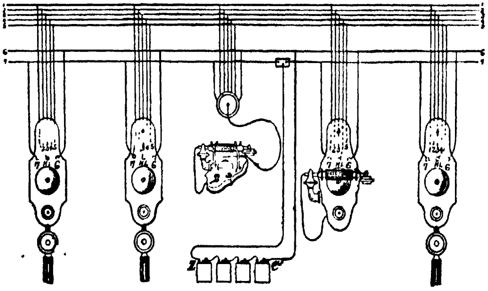


FIG. 201.

necessary cable, with distinctive colour for each line, is run between all stations, and T'd off to the different instruments as shown, by means of junction boxes.

One battery only is needed, and is connected somewhere about the middle of the system. An Inductor Coil with three terminals is required, and connected near battery as shown in diagram. The number of conductors in the cable is always two more than the number of telephones:—Thus for three instruments use a 5-line cable ; for five instruments a 7-line cable. It is well to allow a spare line for additional instrument which might be needed.

Of example circuits in which the instruments have no magneto-call arrangements yet utilise the earth return, Fig. 202 can be taken as the simplest that can be erected, this representing two instruments like the last illustrated (which may be with or without the revolving microphone) connected up with earth return. If desired a return wire can be used; but if the earth is used, then it must be what is called a good earth, or the current may not return properly, or at all. Usually a gas or water pipe is available, and, assuming the pipe passes under the ground (as they practically always do), the return is connected to this. If these are not available, then a pump suction pipe, extending down a well, can be utilised ; but a pipe leading into an underground cistern will not do. If the wire must go to earth direct, neither of the foregoing being available, then it is usual to connect the wire to a copper plate of about four square feet surface, which is buried, and a load of small coke thrown in around the plate before the earth is filled in. It has been found, however, that a piece of sheet lead of about the same size is practically as good as the copper plate. The earth wire should be 16 G, or in larger jobs 15 or 14 G.

For outdoor lines a covered wire is generally used for short distances, and is then run along walls or wherever it can be most conveniently supported ; and, in the case of longer overhead bare lines, it is a covered wire that is used for "leading-in." This latter wire is the one which connects the outside bare wire with the house. The covered wires can be 20, 18, or 16 G, according to their lengths, and some care should be used to give them the most favourable conditions the job will admit. If allowed to sag and swing, for instance, the covering will be worn off, or a badly driven staple will do as much harm more quickly. Staples should be galvanised for outdoor work, and a strip of leather beneath is very desirable. It is well to carry the covered wires beneath eaves and in sheltered places, as both rain and sun shorten the life of the covering.

Overhead bare wires are generally adopted for long outdoor lines, and also for short, as it is usually the more economical arrangement in any case. 18 G is used for ordinary spans, while 16 G is resorted to when the spans are unusually long. These wires, also, should be strained up as taut as possible.

The "leading-in" wire previously referred to joins the bare wire at the last insulator (which is placed as near the point where the wire enters the building as possible) ; and as this wire is outside the building the covering must be of a kind that will withstand bad weather. It may be covered with gutta-percha, vulcanised india-rubber, or tarred tape, and where it enters through wall or woodwork the hole should slant upwards that rain may not enter. The hole is usually lined with lead, compo, or porcelain pipe.

With bare line wires, insulators must be used on the line supports, to prevent leakage or passage of current to earth by way of the pillar, wall, tree or other object that the support is obtained from. Insulators are made of stoneware, which is a non-conductor, and they are of many forms. In every case three principal things are aimed at. First, the insulator must form convenient attachment for the line wire ; next, it must offer no opportunity for the current from the bare wire

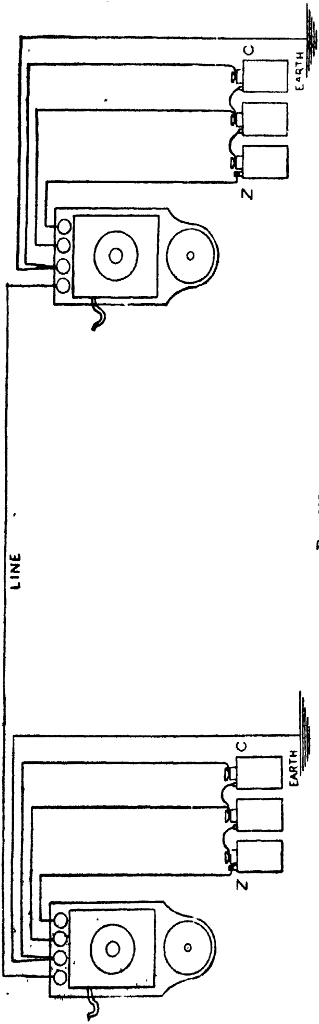


FIG 202.

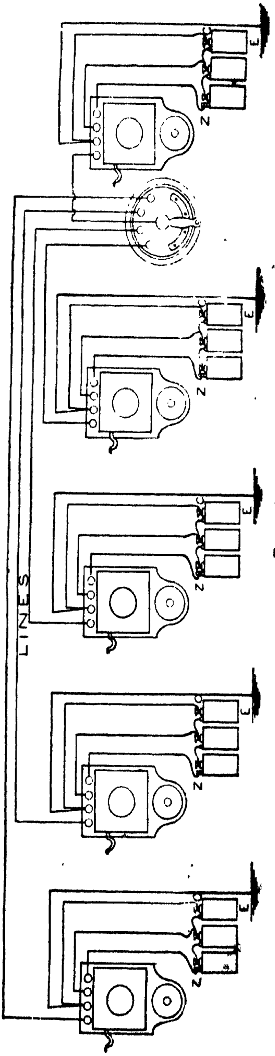


FIG. 203.

to pass to the ironwork which supports the earthenware; thirdly, it must not admit of becoming wet with rain at all parts, otherwise the film of water will act as a conductor for the current to pass from the wire to the support.

When utilising trees as supports, it must be seen that boughs do not touch the wire either when borne about by the wind or weighed down by water. When poles are used the tops are protected with zinc or lead caps, otherwise the weather acting on the end grain will quickly cause the wood to rot. In attaching the line to the insulator it is best to first closely bind over the line, where it comes against the insulator, with binding wire, thus affording protection to the line in case it chafes. The same binding wire—18 G soft copper—is used to secure the line to the insulator, drawing the line well into the groove and securely holding it there. Afterwards it can be soldered, and it may be noted that in soldering the line wire at any point it should be done quickly without excess of heat, as otherwise the joint may prove to be a weak place in withstanding strain. The distance between supports (insulators) should not exceed 100 yards unless absolutely necessary. This distance should be considered the maximum ordinary span, and a little less span is best whenever convenient.

A further diagram of a complete circuit (without magneto-bell) is given in Fig. 203, which is an arrangement the reverse of that given for domestic work, as with this it is planned that one station can call up any one of four others (or more) without being called up itself. This would be adapted for a gentleman's study, that he might communicate with lodge-keeper, estateman, stables, etc.; or, for business purposes, the chief office would be enabled to call up foremen and others in their offices. Conversation both ways would be carried on once communication was made from one to the other, but afterwards the switch would entirely cut off connection. The switch being in the chief office gives the occupant of this room entire control over all lines. It would, however, be possible for one of the other stations to call up the chief office if it was desired and previously arranged. To effect this, the chief station instrument would have a call bell like the others (as illustrated), and the switch, when the circuit was not in use, would be always left upon the stud connecting the favoured station. Thus arranged, a call could be sent equally well either way, but the other three stations would not participate in this advantage. (The Sloper system gives intercommunication between different points with a single switch, as will be found explained directly).

Fig. 204 shows another wiring system by which a chief office can communicate with two sub-offices and can also, when desired, switch the two sub-offices into connection with one another. A relay bell is shown in the chief office (*see* Relays, later).

Fig. 205 shows the plan of wiring by which a central office can call up any sub-station, and any sub-station can call up the chief office, but the sub-stations cannot communicate with each other. No switching is needed in this case, as it is done automatically. This illustration shows an indicator, which in this work is called an Annunciator. This instrument automatically puts the chief offices into connection with whichever sub-office should make a call, and indicates where the call comes from. It is necessary to reset the indicator when conversation is finished.

Fig. 206 is the wiring of three stations, any of which can call or be called by either of the others direct.

Fig. 207 illustrates an Exchange System. Any station can ring up Central (and vice versa) and Central can connect up any two stations. This illustration is for continuous ringing. For non-continuous ringing the connections would be as Fig. 208. Either of these two examples can be arranged for battery-call or magneto-call.

Fig. 209 shows a pair of magneto

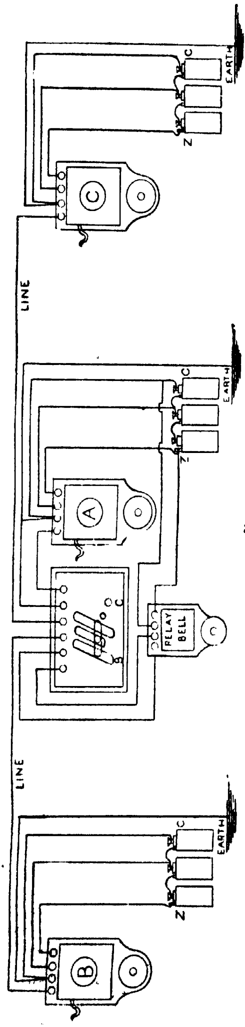


FIG. 204.

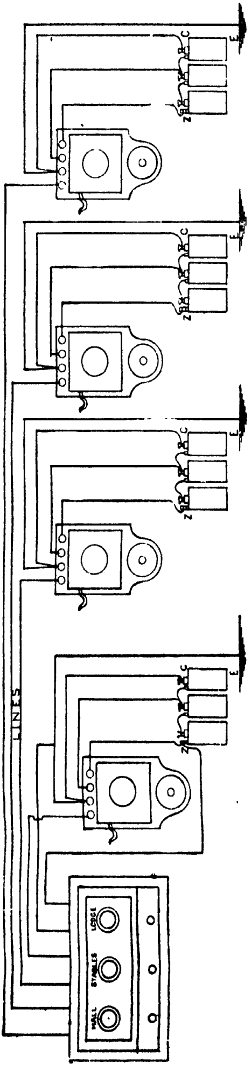


FIG. 205.

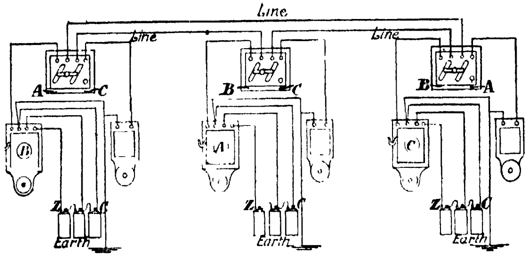


FIG. 206

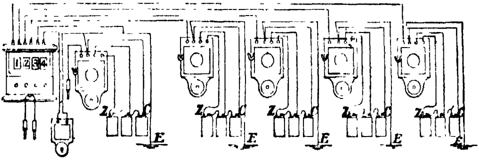


FIG. 207.

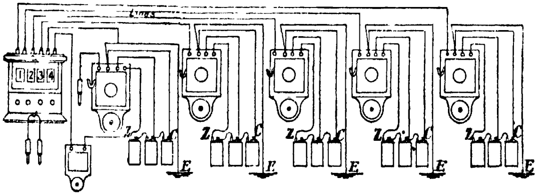


FIG 208.

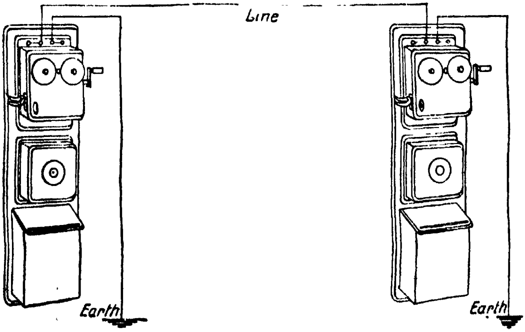


FIG. 209.

telephone instruments with connections between two points.

In Fig. 210 is an example set of wires, introducing "Sloper's Patent" intercommunicating instrument. With these arranged in this way, any one station can ring up and converse with the other, and the mechanism is such that when two stations are communicating they get a complete closed metallic circuit connecting these two only, so that cross talk is avoided and also listening. Only one switch is required to each, and this can be left in any position after communicating, without stopping or effecting further calls. It is an ingenious and good instrument, and no extra wiring is needed. The illustration shows two cells in the microphone circuit. If only one is required, which is generally sufficient, the wire from third terminal of telephone is connected to the next carbon terminal to the left. Connection between any two points can be left out, if desired, without disturbing the remainder.

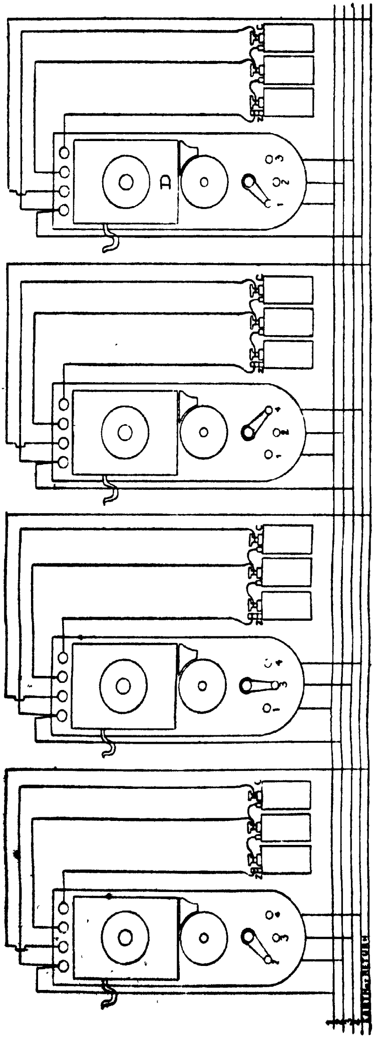


Fig. 210.

Magneto-call Instruments.—For long distance work, or whenever it is desired to avoid the use of a battery for ringing, magneto-bells are used with the telephones. The principle of the magneto instrument is that if a conductor is moved in a magnetic field it will have currents generated in it, and these currents will vary with the movements of the conductor to or from the field. The details of the instrument are, first, a pair of (or three) magnets braced together, these presenting, of course, three north and three south poles. Between the poles, where the magnetic field exists, the conductor is made to revolve, this being a soft iron armature or core, over which, lengthways, is bound a quantity of fine insulated wire. This armature is supported on suitable bearings, but instead of having its axle connected direct to the handle which causes it to turn, a pair of wheels are used which multiply its speed of revolution, which is thus made high. The rapid revolution of the armature causes alternating currents to be set up—that is generated—in the fine wire (which has a high E.M.F.), and the current is capable of overcoming a considerable amount of resistance. That the wire of the armature may be properly connected with the line wire, the axle or spindle of the revolving armature requires to be suitably made, otherwise the wire would be twisted up and broken in a few moments. This is usually done as Fig. 212, which shows the spindle with one end bored out about three-quarters of an inch deep into which a pin is inserted with a vulcanite lining around it. This insulates the armature core from the pin, but the current from the armature wire is made to pass by the small pin marked P. This small pin is also insulated from the core by a lining of vulcanite. The current is taken from the larger pin by a spring which is arranged to press against it. A special form of bell is needed for this current, and Fig. 211 shows the principle it works upon. The alternating current makes the top armature rock as rapidly as the current alternates, causing a succession of rapidly delivered blows to be dealt on the bells above. Fig. 213 shows a magneto-generator and bell in case complete. When the receiver is on the hook of a magneto instrument the generator and bells at both ends are in connection. Thus the turning of the handle sends a magnetic current to make a call, and then as soon as the receiver is lifted off the hook for application to the ear the battery circuit is completed and conversation can take place. It should be noted that annunciators as well as bells have to be differently constructed for magnetic currents than for battery currents.

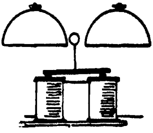


FIG. 211.

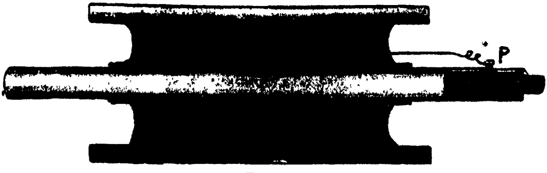


FIG. 212.

Lightning Arresters.—All telephones, excepting those for indoor circuits only, should be fitted with lightning arresters, a device by which lightning is conducted to the earth should it discharge itself to any extent through the line wire. The silk or cotton insulation of telephone wires is amply sufficient to withstand the low force employed in this work, but no ordinary insulating covering will resist lightning, with the result that the instruments would be destroyed if this greatly superior force passed through them. Not only are instrument sets provided with arresters, but circumstances, or a desire for the utmost safety possible, make the use of arresters at intermediate points quite common. Fig. 214 is the usual form of arrester that appears on instrument sets, the line wire having a connection with one half while the other half is connected to earth (either to the earth wire of the instruments or separately).

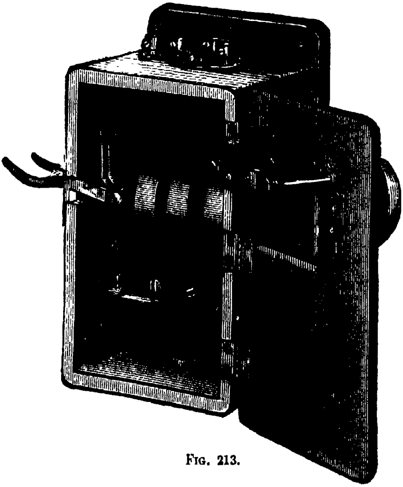


FIG. 213.

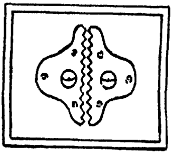


FIG 214.

The arrester relies for its efficiency largely upon the tendency that electricity has of discharging itself from and to points, assuming, of course, that the points are not too widely separated. This device has the points sufficiently wide apart to prevent the low current used for the telephone from jumping across, but with the E. M. F. of lightning the current passes almost the same as if they touched one another. An arrester with three plates is used when connected to a pair of lines separately from the telephone. Arresters for separate use are also made much like the ordinary cut-outs that appear in electric light circuits. A strip of fusible wire introduced in the line can be relied on to stop a heavy charge of electricity, and when melted it can be easily and quickly replaced.

Relays.—A relay consists of an electro-magnet which, when a current is sent through, causes a contact to be made with a battery in connection with it, thus giving fresh force to the current on its way. It is a means by which new or extra power can be given a current on a long line. Sometimes, when the conditions make it favourable, a weak current is used to work the relay magnet, which then brings a more powerful battery into play for the work required of it. A "Relay Bell" is generally that which is an extension from the telephone, or it may be an extra bell as shown at Fig. 204, in which case it is connected to the instrument battery. This is much better than attempting to ring a bell connected up in series. Continuous ringing relays can also be had, these causing the bell to ring continuously until stopped by the person answering the call.

Fig. 215 illustrates one of Gent's relays for telephone work. When the armature, which is ordinarily resting against the top screw G, is drawn down on to the magnet by the current which passes through C, it brings about a contact between A and B to which the wires D and E of the secondary battery are attached. Relays are made with single magnet, as shown, or with double magnet.

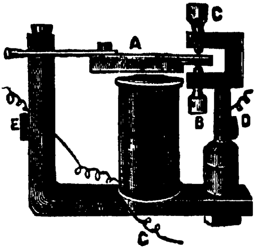


FIG. 215.

Home-made Telephone Instruments.—(*a*) I have been for some time engaged in endeavouring to arrange a telephone switch-board and telephone transmitter which should be simple, easy of construction, effective in operation, and not an infringement of any patent. I believe that I have fully succeeded in all these objects; a patent for the arrangement could only be valid as for a particular combination of parts, and as the combination of parts is susceptible of so many variations a patent would be practically useless. The following description will enable any amateur to make them :—

Switch-Board.—Take a piece of mahogany 8 in. by 4 in. by 1 in., plane it up and varnish it. On the top, at a distance of $\frac{3}{4}$ in. from the top, fix seven terminals, $\frac{1}{2}$ in. apart. These are numbered in Fig. 216, 1, 2, 3, 4, 5, 6, 7, and are for the following connections: 1, 2, 3, are connected together by the brass plate as shown; 1 is connected to the return line or earth wire; 2 to the zinc pole of the battery; 3 and 4 to the bell wires; 5 to the carbon pole of the first cell; 6 to the carbon pole of the last cell; and 7 to the line wire. P is a strip of brass with the knob K at the lower end; it is secured by two screws at the upper end, and is then bent upwards so as to press against the bridge B, which is a strip of brass secured by the screws at each end, each of which screws passes through a piece of brass tube which keeps the plate B about $\frac{1}{4}$ in. from the board. The piece P is connected by a wire underneath the board (all the connections are made underneath), with the terminal screw 7. Under the knob K is a screw with a flattened head, which is connected with terminal screw 6; this constitutes the ringing key. H is a piece of $\frac{1}{4}$-in. brass rod with the hook at the bottom, and the round brass disc D about $\frac{7}{8}$ in. diameter, soldered about $\frac{1}{2}$ in. from the upper end; this rod works freely up and down through the two pieces of angle brass A. S is a spiral spring of brass wire which, when the telephone is taken off the hook, causes this rod to rise, and the disc D then presses the thin pieces of hammer-hardened brass C against the upper angle brass A. In order to ensure a good contact, this strip of brass C is slightly canted at the end so as to give two rubbing contacts, one against the disc D and the other against the upper angle brass A. When the telephone is on the hook, the disc D rests on the piece of brass R, which acts as a contact and as a stop. The total play allowed to D is about $\frac{3}{16}$ in.; the lower angle brass A is connected with the bridge B; the piece of brass R is connected with the terminal 4; and the thin piece of brass C with the upper hinge. T and T^1 are brass screws to which the flexible wires of the telephone receiver are attached; T is connected with terminal 5, and T^1 with the lower hinge. M is merely a piece of mahogany to which the pieces C and R are attached.

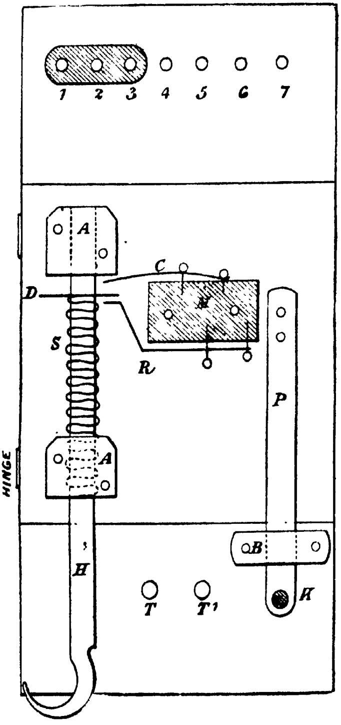


FIG. 216.

We now require a square frame of ¼ in. mahogany, 4 in. square in outside measurement, and 1⅝ in. deep; apertures are cut in the bottom side of this to allow the rod H and the ringing key P to move freely. This case is attached to the hinges marked, and with a face piece of pine about ⅛ in. thick, boxes up the whole of the apparatus, leaving only 2 in. of the board at the top, and the same at the bottom uncovered; a small plate of brass is screwed to this box opposite to the hinges, and one screw into the switchboard prevents the box from being opened.

To the centre of this piece of pine the microphone transmitter shown in Fig. 217 is attached.

This microphone is thus constructed: Take a piece of pine about $\frac{3}{16}$ in. thick, ⅞ in. wide, and 1¾ in. long; remove part of one edge so as to leave a projection as shown, and about $\frac{1}{16}$ in. deep, and $\frac{3}{16}$ in. square, by which it is attached to the centre of the pine face of the box; put a sawcut down through it to within about ¼ in. from the bottom. Take two pieces of ¼ in. carbon rod, E, 1⅛ in. long, and cut a recess in the middle of each half-way through, and a little more than $\frac{3}{16}$ in. wide; drill a small hole in the middle of each recess; bend a narrow piece of very thin sheet brass over the top of each arm or leg of the piece of pine; solder a wire to each piece of brass, and then secure the carbons by screws to the piece of pine as shown in E. These pieces of carbon should be parallel, level, and a little less than ⅛ in. apart; the wire from one carbon is taken to the top hinge, and from the other to the bottom hinge. Some of the carbon rods now sold have a coating of glaze, which is almost a non-conductor. Always remove this with emery-paper. This piece of pine with the carbons attached is now screwed to the centre of the pine cover of the box, and care must be taken that it does not touch anywhere else, and is not touched by anything. The microphone is completed by making two small conical pieces of carbon N, as shown, with a small hole in the centre of each; a lucifer match or other small piece of light wood is then filed or sand-papered down until it is as small as a knitting-needle, and will just go into the holes in the carbon cones. In one carbon cone, put a piece of this wood about ½ in. long, and in the other carbon cone a piece about ¾ in. long, and round the bottom of each of these pieces of wood put a small ring of lead wire; they are then put in position on the carbon rods, and appear as shown in Fig. 217, end view, where E is one of the horizontal pieces of carbon rod, and N the carbon cones; they should oscillate freely. Cut these carbon cones from $\frac{3}{16}$ in. rod.

I do not advise the use of induction coils with transmitters, and the above-described switch-board must be altered and made more complicated if they are used; but the arrangement is suited for any good receiver. In connecting up two stations, it will, of course, be remembered that the battery connections at one station must be reversed; that is, the carbon wire attached where I have directed the zinc wire to be attached, and the zinc wire attached where I have directed the carbon.

For battery power, I find that the battery required to ring a fairly good ordinary bell works this arrangement well; thus, if two Leclanché cells ring the ordinary bell nicely, then put one Leclanché cell at each end of the line in circuit with the telephone; if three Leclanché cells are required to ring the bell, then put two cells at one end of the line, and one cell at the other end in circuit with the telephone.

I have omitted to mention that outside the pine cover to which the microphone transmitter is fixed, I screw by its four corners a piece of cork 3½ in. square and about ¼ in. thick, with a ⅝-in. hole punched out of the centre. This damps all the sound vibrations, except where they are alone required,

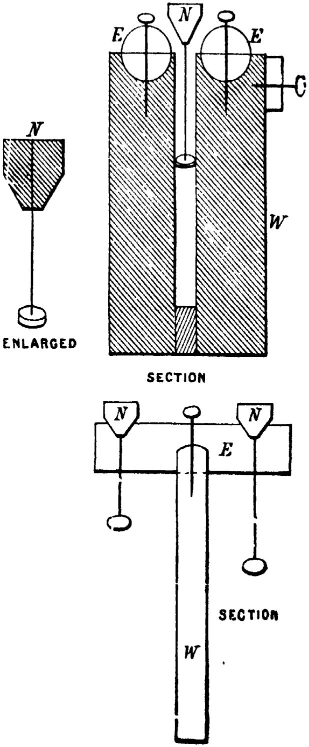


FIG. 217.

that is, in the centre where the microphone is attached, and is a great improvement. (H. B. T. Strangways).

Mechanical Telephony.—A good working string telephone may be made as follows: Make two tin drums 6 in. diameter and 4 in. deep. They should have a heavy wire formed in same as ½ gal. cup. The wire should not be less than No. 9. Take raw hide that has been divested of hair, stretch it over the drum while wet, and bind it on with a small wire; let it remain till perfectly dry. A very thin hide, such as squirrel, cat, coon, is the best. Thick hide will not work well. Now to erect your drum, wire, etc.; having set your posts and put up your insulators, which may be made of wire and suspended from arms which have been nailed to the posts, bore a hole in the wall where the drum is to be placed, run the wire through your drum and through the raw hide in the centre, having a button ready. Pass the wire through the eye of the button and back through the drum and twist tightly, letting the button go, resting it on the hide. Put up the wire at the different insulators (string loop suspenders) till it reaches the other end of the line; then proceed to do as at first. If the wire has been properly stretched, and all the work has been done as it should have been done, you will have a good and cheap telephone. No. 18 copper wire for main line should be used. ('American Artisan.')

Connecting Bells and Telephones.—(*a*) Bell and Telephone.—It is a very easy matter to add telephones to bell signalling appliances, when constructed as here described. The only additions necessary are a branch or return circuit for the telephones, and a switch operated by hand, whereby the main wire is switched from the bell return wire to the telephone return wire. A very simple plan for a bell-call and telephone line from one room to another can be made as follows: Apparatus required—two bells, two telephones, two 3-point switches, two strap-keys with back and front contacts, and one battery. Run one wire from the stem of the key in room No. 1 to the stem of the key in room No. 2. This is the main wire. Fix the bell and 3-point switch below it in each room. Connect the back contact of each key by wire to the lever of the 3-point switch, attach one of the points of the switch to one of the bell terminals, and the other bell terminal to a return wire. The return wire will now connect the second bell terminal in one room with the second bell in the other room. The other point of the switch in each room is now connected by a wire with one binding-screw of a telephone, and the other telephone screw is attached by another wire to the bell return. Connecting one pole of the battery also to the return wire, and the other pole to each of the front contacts of the keys, the system is complete. When at rest, each switch is turned on to the bell. To ring the bell in the other room, the key is pressed. The battery circuit is then from battery, front contact of the pressed key, stem of key, main wire, stem of distant key, switch, bell, and through return wire to the other pole of the battery. After bell signals are interchanged, the 3-point switches are transferred to the telephone point, and conversation can be maintained. (Lockwood.)

(*b*) Connecting Bells and Telephones by one Wire.—Use a relay, as shown in Fig. 218 at *a*. The switch *b* has three knobs, Nos. 1, 2, 3. The handles of both switches must be turned on No. 1 when not in use, awaiting calls, both on No. 2 for telephonic messages, and either on No. 3 for ringing bell to call attention at the other end. It would be better to have the bell single stroke (the connections make the difference), and the relay will make it continuous. Make the relay of small size, and to fit in at the back of the switch. The action of the relay is thus:—When handle is turned on No. 3 right-hand switch, a current of electricity is sent through wire to the other end, through

No. 1 knob to electro-magnet in relay, which draws down the spring until it touches the other wire, which sends a current through the battery, and strikes the bell. The other connections will explain themselves.

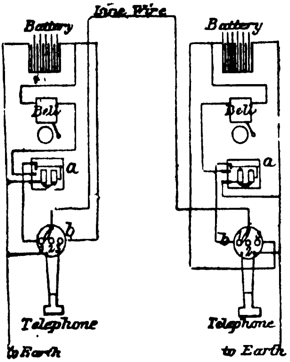


FIG. 218.

(*c*) Connecting Telephones and Bells.—In Fig. 219, *d* is a piece of brass shaped like the shafts of a cart (only the telephone takes the place of the horse), secured to the base-board by a short piece of steel spring. The telephone by its weight brings *b* into contact with *c*, thereby breaking communication with the speaking instrument, and bringing the bell *e* into readiness for receiving a signal. Directly the telephone is removed, *d* springs up, making contact at *b a*, so bringing the telephone into connection with the line wire *f*. As shown in the sketch, the bell is ready to receive a signal from the distant station, but by pressing down the spring *g* (similar to the key used for the Morse telegraph), you cut off connection at *h*, and bring your own battery into action, thereby ringing the bells. The board should be suspended against a wall.

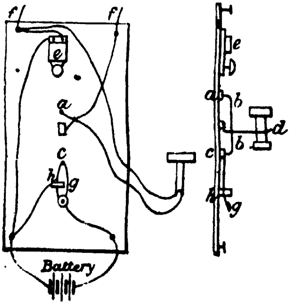


FIG. 219.

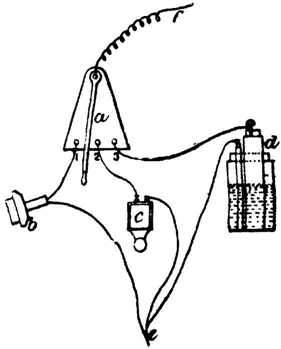


FIG. 220.

(*d*) Another plan.—Make connections like Fig. 220 at both ends: *a*, switch; *b*, telephone; *c*, bell; *d*, battery; *e*, earth (water or gas-pipe will do); *f*, line-wire. The switch is made of a piece of wood with three studs at bottom, connected with the wires as shown. A strip of brass is made to slide over them so as to make contact, and communicate with line wire. When not in use, the handle must be in contact with the centre stud at both ends, to call attention at the other station. Put the switch to No. 3 stud, which will ring his bell for a few seconds, and put your switch back to stud 2. The other station now must just do the same to let you know that he is there, and as soon as the bell stops ringing, move the switch to stud 1 to connect telephones. The other station must move his switch as soon as he has rung reply to your call. You can now go on with your speaking, and as soon as finished move switch to stud 2 at both ends.

(*e*) Another plan.—The push in Fig. 221 is of rather peculiar construction. A spring *a* is connected, through a binding-screw *b*, with the line-wire *c*, and is fixed so that the free end plays between two contact-pieces *d* and *e*, the former of which is connected with the telephone *f*, the latter with one pole of the Leclanché cell *g*. The other pole of the battery is connected to the return wire, or, in the case of there being no return wire, to earth. The normal position of spring is as shown in section, pressing against *d*. The telephone *f* is thus in circuit. By pressing the stud, the spring is brought into contact with *c*, and the bell *h* at further station rings.

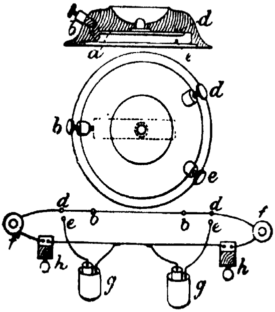


FIG. 221.

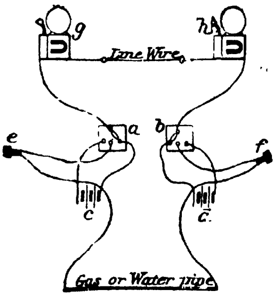


FIG. 222.

(*f*) Another plan.—The following method of connecting bells and telephones with one wire has the advantage that the telephones are thrown out of the circuit while the bells are ringing, and thus not subjected to the battery current, wherefore perhaps it is to be preferred. In Fig. 222, *a b* are two switch arrangements, having a movable arm fixed to the top button, capable of sliding over the lower three, and making contact with either. *c* and *d* are the batteries, *e* and *f* the telephones, and *g* and *h* the bells. In the diagram, the switches are shown in the position in which they are always left after using. Then, by turning either of them on to the end button, both bells ring, thus letting the ringers know that the circuit is complete. The switch is then moved back for the answer. When that has been received, both switches are moved to the middle button, which brings the telephones into circuit, and conversation may be carried on. It is necessary to remember to move the switches back after the conversation is finished. This arrangement is used over 300 yd. of uninsulated copper wire, which is carried over the roofs of several houses and across three streets without any insulation whatever, and the gas-pipe is used for the return circuit. It employs three Leclanché cells of 1 pint capacity; two were not powerful enough. This has been in use for several weeks, and the weather does not seem to have had any bad effect on bells or telephones. A wrinkle connected with the telephone is, that the strength of the magnet makes more difference than some might suppose. A pair which were working miserably, when taken to pieces, and the magnets re-magnetised, work splendidly. Iron cores do not make any perceptible difference for ordinary purposes, and ⅔ oz. of wire works perhaps rather better than ¼ oz., but there is very little difference.

* * *

TEMPERING AND HARDENING METALS.

Casehardening.—(*a*) To caseharden iron, procure a quantity of old boots or other discarded leather goods, burn these until they become charred, beat off the black and charred portion with a hammer, until sufficient powdered carbon is obtained; then place this powder with the articles to be operated upon in a sheet-iron box or a piece of wrought-iron gas-pipe sufficiently large, taking care that the articles are well covered and in the centre of the mass; lute the ends or top of the box with clay, and place the whole in a fire made of coke, keeping them there for an hour or more, taking care that the heat shall be equal (between dark-red and red); now plunge the contents into water. Should the articles require to be blue, such as the barrels or chambers of pistols, repolish them on an emery wheel, and put them into a sand bath or powdered charcoal, until the blue colour is attained, taking them out immediately this change takes place. The following are mixtures that will do instead of the burnt leather: 3 parts of prussiate of potash to 1 sal-ammoniac; or 2 parts sal-ammoniac, 2 bone-dust, 1 prussiate of potash. Bones, urine, and night-soil, are also used for this purpose. A simple method of casehardening iron is to sprinkle powdered prussiate of potash over it at a red heat and plunge into water; bichromate of potash, with the pith of rams' horns, may be used with good results, instead of the prussiate.

(*b*) Casehardening consists in changing a thin surface layer of either cast-iron or machine-steel to hardened steel, leaving the interior unchanged and as tough as it was before the treatment. There are several methods for accomplishing this end, the comparative merits of which will not be entered into here; the best results are obtained by processes too long and cumbersome for the ordinary individual to use; but there is a quick and easy way which, while not penetrating the metal to as great a depth as might be wished, is still of sufficient service to well repay for the small expenditure of time and labour involved; it is so easily done and of such benefit that there is little excuse for makers or even users of automobiles neglecting to give at least some of the smaller parts a hard coating that will protect them from wear so far as may be. Bolts, nuts, pins, wrenches, etc., should be casehardened, both to increase their durability and to preserve their good appearance. Take, for example, the parts which are manipulated in tightening clutches and brake bands; the screws and lock-nuts are sometimes so located that the wrench will not go on the nuts and screws in good shape, and then, even if the wrench fits them, the corners are liable to become so rounded that it is difficult to make the necessary adjustments, and at the same time the parts are given a most unsightly appearance, which offends the mechanical eye to no small degree. Any bolt or nut which requires occasional tightening should be hardened, even if it is so located that the wrench is easily applied. Journals must be hardened if the best service is to be obtained; there is no question but what hardening a bearing makes it run easier, as well as with less wear.

Sometimes a special tool must be made for some special purpose, and if it is to be used but little it can often be made of iron, then casehardened and made to answer the purpose.

An easy and quick way to caseharden is as follows: Heat the article to a dull red by means of a gasolene torch or by any other suitable means, and then apply a lump of potassium cyanide to it, causing the fused chemical to flow over every part, then heat to a cherry red and plunge into cold water. Sometimes a bath of salt and water is used instead of plain water for the cooling.

Potassium cyanide is one of the most deadly poisons, and care should be observed both in keeping and handling it. It should be kept in a tightly corked bottle so that the air will not reach it, and should be handled as little as possible, and its fumes avoided. Some workers will not use cyanide because of its dangerous nature, but use yellow prussiate of potash instead; equally good results are sometimes claimed from the use of the yellow prussiate, but it is not so generally liked, one reason being that it does not so readily fuse and flow over the work as cyanide.

Different samples of iron behave differently, some requiring more heat than others in order to produce the required degree of hardness. The part should not be heated too much, or the surface may become pitted or roughened. ('Horseless Age.')

(*c*) For casehardening we use prussiate of potash, pulverised and mixed with fine salt, about equal parts. We heat the pieces to be hardened, apply the potash and immerse while it is flowing. I wish to emphasise this. Many smiths hold the piece until the potash is burned off. This is a mistake. It should be dipped while the potash is in a liquid state, as otherwise the piece will not come out as hard as it should. If we want a piece very hard we sometimes use cyanide of potassium, and heat in an ordinary forge fire; but this method is resorted to only when there are but a few pieces to be hardened.

We very often have pieces to harden, such as steps, centres, cups, and tracers, which require to be soft on one end so that they can be riveted after hardening. For this purpose we use "Carburizer." The pieces are packed in a box made for the purpose about 5 in. by 3 in. by 1½ in. deep.

A layer of carburizer is put in first; then the pieces are placed in the box, with the ends down that are to be hardened; the mixture is then filled in over and around the parts that are to be hardened, the quantity being proportioned, as nearly as possible, to the depth of hardening required, and the parts that are not to be hardened are covered with slaked lime.

The box is then placed in an idle forge and kept at a good heat for an hour or more, according to the size of the work. At the end of the heat, before quenching, the fire is forced so that the pieces may be hardened on a rising heat; they are then dipped. If the operation has been properly done the pieces will be glass-hard where covered by the carburizer and soft where covered by the lime. ('Sparks from the Anvil.')

(*d*) In the writer's opinion, the best material to be casehardened for guides, links, link lifters, blocks and saddles, eccentric rod jaws, and all motion work, is No. 1 fibrous hammered iron. In preparing this iron the pile should be large enough, the heating perfect and the manipulation under the hammer sufficiently skilful to produce a refined perfectly welded iron, free from longitudinal seams or sheared fibres, as frequently caused by disregarding these essentials.

We do not think it advisable to use granular iron for any purpose where casehardening is required. To do so would greatly decrease its reliability, owing to the shortness of its initial structure; nor would we recommend merchant bar iron, with its rawness, lack of density, and containing, as it does, too great a percentage of slag, all of which a single working or simply the forming into shape will not fully rectify.

The penetration of the carbon in casehardening depends upon the medium used, upon the compactness of the iron, and the length of time it is subjected to the required temperature, which is about 1550° F. Guides made of good hammered iron should remain in the carbon, after becoming red-hot, from 20 to 24 hours. A carbon penetration of $\frac{3}{16}$ in., or even $\frac{1}{8}$ in., is none too deep for them. Lighter articles, such as links, and all motion work, will have the proper penetration of carbon, $\frac{3}{32}$ in., after being held at the right temperature for from 15 to 16 hours.

The proper temperature for casehardening runs from 1550° to 1700°, and can be easily recognised by the experienced eye. Any railroad foreman smith should be perfectly familar with the proper temperature, or low shade of red heat, for steel hardening and annealing purposes, which runs from 1400° to 1500°.

As to the medium for case-hardening, some use charcoal, some carbonated bone black, and some use a compound of yellow prussiate of potash, soda ash, salt, etc., and all get fairly good results. It is claimed that old leather belting, old shoes, etc., meet all requirements as a case-hardening medium, but it would barefoot a whole army to furnish enough old shoes to case-harden the engine motion work on one of our many railroads to-day.

I have used many mixtures to coat iron with steel, and I wish to acknowledge my indebtedness to Mr. John Buckley, of Chicago, whose statement at our meeting in Pittsburgh in 1894, as to the results he obtained from granulated rawbone, prompted me to give it a trial, and I am still using it in preference to anything else, whether on the market or home made. It is cheap, always ready for use, easily handled, does excellent work, and all the rats in the neighbourhood would grow fat on it if you did not protect it.

As to furnaces for case-hardening purposes, there is no doubt but that some are more convenient than others, yet with a furnace of any kind, when the same medium is used, and the same uniform temperature and time are secured, the results will be equally good.

In the shops which I have charge of we use a furnace of the style in use in most railway shops: inside dimensions 8 ft. by 2 ft. by 6 ft., built of firebrick, incased with old tank plates, and three 3-in. perforated pipes running through the bottom lengthwise. We use coke as fuel. Our boxes are cast-iron 10 in. by 10 in. by 36 in. for motion work; for guides, etc., 12 in. by 12 in. by 40 in. to 70 in. in length. We pack in the customary way, alternating layer after layer of rawbone and the iron, placing a cast lid on the box and sealing with fireclay. We also insert two iron test pieces ¾ in. diameter through the end of the box, and withdraw one at five hours, the other at six hours after placing the box in the furnace. We then know the temperature of contents of box, and date our time limit accordingly. We quench in a water-tank 42 in. diameter by 6 ft. long, let into the ground level with floor line, with an inlet pipe at the bottom and an overflow pipe at the top. (A. W. McCaslin).

It is possible to harden machine steel in such a manner as to produce a fine grain; in fact, as fine as that of the nicest tool-steel. Cams made of low-grade steel and hardened by this method will resist wear as well as though made of tool-steel and hardened, and they are not as liable to flake off or break. Punch press dies for light, easy cutting metals, where there are no projections, will do very satisfactory work. Gauges, whether they be snap, plug, and ring or receiving, can be hardened with much less liability of going out of shape, are easier to make, and will wear as long as though made of tool-steel.

Many bicycle parts formerly made of the best steel are now made of machine steel, and excellent results are obtained. Such is not apt to be the case if they are simply case-hardened by the ordinary method, as the grain is too coarse to resist the peculiar action of the balls, particularly on the cones and ball seats or cups. Spindles of machines, where there is considerable tendency to wear, also a pounding or yanking motion to resist where hardened tool-steel would be liable to break and ordinary case-hardening would yield to such an extent as to make the bearings become out of round, can be treated very successfully by this method.

All that is needed is a good hardening oven, large enough to receive as many hardening boxes or pots as we may need, a plentiful supply of pots, some granulated raw bone, a good supply of granulated charcoal, a small amount of hydrocarbonated bone, and some charred leather for our nicest work. We should have a plentiful supply of water in a large tank, a smaller tank arranged that we can heat it to any desired degree, and a bath of oil. Raw linseed is the best for giving a hard surface.

Pack the work the same as for ordinary case-hardening, run about the same length of time, and leave in the oven to cool, the same as for annealing. When it is cold, a piece can be heated in the lead pot, and hardened the same as tool steel, or, if the articles are small, and there are many of them, they can be repacked in the hardening-pot with granulated charcoal, but not with any form of bone or leather or any carbonising substance, as that would have a tendency to open the grain. The object of the second heat is to close the grain. The lower the hardening heat the more compact it will be. This method not only gives a close grain, but a very strong, tough surface, and, the centre being soft, the piece is very strong.

When hardening tools whose office it is to cut metal, it is always best to use for a packing mixture equal parts of charred leather and charcoal. The kernels should be fine, and about the same size if possible, to keep them from separating, as if there were much difference the finer would sift to the bottom. Leather gives a stronger, tougher effect than bone, it being practically free from phosphorus, while bone contains quite a percentage. The presence of phosphorus in steel makes it brittle. Yet for most purposes, where there are no cutting edges, bone is a very satisfactory carbonising agent to use in connection with machinery steel, and is much cheaper than leather.

When using either bone or leather, mix with an equal amount—by measure—of granulated charcoal. Being well mixed, the particles of charcoal keep the kernels of bone or leather from adhering to each other and forming a solid mass when heated.

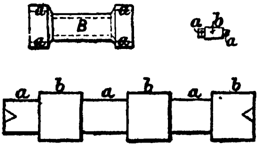
When hardening small pieces that do not need carbonising more than $\frac{1}{32}$ in. deep, it is best to use No. 2 granulated raw bone; pieces that require a very deep hardened section need a coarser grade, as they must be run longer in the fire.

In casehardening bicycle cones, where it is necessary to carbonise quite deeply, it is best to pack with No. 3 bone and charcoal, equal parts, or better still, with 2 parts raw bone, 2 parts charcoal, and 1 part bone-black or animal charcoal. Pack in the hardening box, as previously described in article on casehardening; run in the oven ten hours after the box is heated through. To determine the time use test wires running down from top to bottom of box, as previously described. After the work is cold, it can be reheated in the lead pot and hardened. Drive a wedge into the axle hole of one of the cones and split it open to see how deep you have penetrated; if not deep enough, repack with fresh material and run again. But if directions given are closely followed, the results will probably be found satisfactory. The grain, as far in as the carbon has penetrated, should be as fine as that of hardened tool-steel.

In hardening ball-cups or seats made of machine-steel, pack in a mixture of equal parts of charred leather and granulated charcoal, and run six hours after the box is heated through. When cool, heat in the lead pot and quench in a bath of raw linseed-oil. Leather is used because the cups are generally quite thin and require toughness as well as extreme hardness.

Some articles need the ends hardened, while it is desirable to have the centre soft. Take, for instance, the piece shown in Fig. 223. The surfaces of the ends marked *a* need hardening, while *b* should be soft. Pack the ends, inside and out, with hydrocarbonated bone and charcoal, having previously filled the centre with expended bone, run seven or eight hours after hot. Heat the ends separately in the lead-pot, dip in a bath of lukewarm water, dipping with the heated end up, as steam would prevent the water from entering the end. If water cannot enter work it certainly cannot harden. If this piece is dipped with the heated end up, the water readily enters; the ends will be found to be extremely hard and the grain very compact.

When it is necessary to harden the centre of a piece and to leave the ends soft, it can be readily accomplished, provided the ends are smaller than the centre. Take, for instance, bicycle chain studs, Fig. 224. Take wire in such lengths as can be put into the longest hardening box we have, pack with raw bone and charcoal, run three hours after box is heated through. When cool put in the screw machine and cut the ends to size. When the machine work is completed, heat in a tube and dump in water. Having cut the stock below the carbonised surface on the ends they cannot harden: while the centre will be hard, the ends, being soft, can be riveted in the chain.



FIGS. 223, 224, 225.

A very interesting experiment can be tried, in itself of no practical value, except that it familiarises one with the action of carbon on steel. Take a piece of open-hearth steel, turn in the lathe as shown in Fig. 225, neck in every inch to a depth of $\frac{1}{8}$ in., leaving the intervening space 1 in. long. Pack the piece with raw bone and charcoal, run five or six hours after the box is heated through. When cool turn shoulders marked *b* to size of *a*, leaving *a* the same as before charging. Heat to a good red, and dip in the bath; *a* will be found to be hard, while the spaces between will be soft.

I have mentioned timing the heats from that period when the box was heated through in each instance, because in most places it is customary to time from the putting of the pots into the furnaces—a very uncertain way. If the test-wires mentioned in previous article are used, and time is reckoned from the time the work is red, we shall get uniform results, as the work does not take carbon to amount to anything until it is red hot.

I have also mentioned open-hearth steel. This, if used, will give uniform results, whereas if Bessemer steel is used everything is confusion, as it runs so un-uniform. (E.R. Markham, in the 'American Machinist.')

New Iron Hardening Process.—Phosphorus, as is well known, has the property of imparting a certain degree of surface hardening to iron, but not without producing brittleness. The iron is made to assume a coarse structure, in which the crystals are comparatively loosely bound together. This effect of phosphorus of loosening the coherence of the molecules of the iron greatly facilitates the absorption of carbon by the iron. The carbon rapidly penetrates the iron to a considerable depth, imparting great toughness to the core, and nullifying the comparatively slight defect constituted by the inconsiderable brittleness of the surface. Two Prussian inventors apply this principle in their process for hardening iron by heating the same in a tempering-powder consisting of organic nitrogenous substances containing a high percentage of fusible ash and employing phosphorus as the medium for the introduction of carbon into the iron. Without prejudicially affecting the welding properties of the iron, it imparts such a degree of hardness thereto that it can neither be cut nor chipped by the best steel used. In order to harden the surface of about 200 kilogrammes (441 lb.) of iron to a depth of 1 millimètre (0·0394 in.) by means of this process, the pieces should be imbedded in a retort, muffle, or the like, in bone-dust, to which is added a mixture of 300 grains of yellow prussiate, 250 gr. of cyanide of potassium, and 400 gr. of phosphorus. The receptacle is well closed, luted with clay, etc., and raised to a clear red or white heat, whereupon the material treated is immersed in a glowing condition in a water or other bath. ('Scientific American.')

A few Points in Hardening.—It sometimes happens that a hardener has a long article that must be hardened its entire length. The piece is carefully heated, dipped in the bath, and worked up and down in the most approved manner, yet, when tested, it is found to contain soft places, or, possibly, the end that entered the water first will be found hard, while the opposite end will be found soft, or not as hard as it should be.

At other times it is necessary to harden a large twist drill or similar article that must be hard, in the bottom of the flutes. When a tap, reamer, or any tool whose cutting surfaces are at or near the periphery of the piece is hardened, very satisfactory results are obtained if it is quenched in a still bath—that is, one whose contents are not in motion as the cutting-edges are exposed to the action of the bath—and it is not essential that the portions at the bottom of the groove be hard. In the case of a twist-drill the portion at the bottom of the groove becomes the point of the drill as the tool is ground, consequently it must be hard there.

If the drill is an inch in diameter or over, the more bulky portions constituting the loads hold so much heat that they produce a vapour when in contact with the water, which prevents the water from getting down into the groove in quantities sufficient to harden that portion. The extreme point, being exposed, is hardened, but as the drill is ground, it becomes soft on the point and consequently must be re-hardened.

In order to accomplish the desired result in a satisfactory manner, it is necessary to have a bath so arranged that water can be forced to the bottom of the groove, thus overcoming the tendency of the vapour to keep the water away. If the piece to be hardened is short, this may often be accomplished with a bath having a jet of water coming up from the bottom; but if we are dealing with a long piece, it is advisable to use a bath having several pipes coming up from the bottom which are perforated so that the water is projected against the piece. Very satisfactory results are sure to follow the use of this bath.

An experience of a number of years has convinced me that steel is much stronger and will give better results in every way if it is not overheated. Should it by accident become overheated though not burnt, it can be restored, so far as the appearance of the grain is concerned, at least, by reheating to the refining heat. Steel always shows by the appearance of the grain the effects of the last heat it receives. It should, however, be allowed to remain at this heat long enough to become heated equally throughout the piece.

Steel tools are sometimes made stronger and tougher by heating to a red and plunging in oil, sperm, or lard, allowing them to remain until nearly cold, and then reheating and hardening in the ordinary manner. This, however, should not be tried on articles so small or thin that they will harden in the oil, or strains are set up that may cause them to crack when hardened. If the above is tried, the heating should be very carefully done in a furnace where the article is removed from the air, or the surfaces will be decarbonised.

The best advice that can be given the young hardener is never to overheat a piece of steel, but if by chance that should happen it can be in a great measure restored by reheating properly. Should it be burnt, the mixture given may be tried, though I do not guarantee it. (E. R. Markham, in the 'American Machinist.')

Tempering. *Influence of Temperature.*—Perhaps the best method ever discovered for tempering steel, resulting in hardness, toughness, and elasticity combined, is that followed in hardening the blades of the famous Damascus swords. The furnace in which the blades were heated was constructed with a horizontal slit by which a current of cold air from the outside entered. This slit was always placed on the north side of the furnace, and was provided on the outside with a flat funnel-shaped attachment by which the wind was concentrated and conducted into the slit. The operation of tempering the blades was only performed on those days of winter when a cold strong north wind prevailed. The sword-blade, when bright red hot, was lifted out of the fire and kept in front of the slit, and by this means was gradually cooled in the draught of air. It acquired the proper degree of temper at the single operation. From this account it may be seen that gradual cooling is to be preferred to sudden cooling. While water has been used in the process of tempering for a long time, it was only at a comparatively recent date that hot water was used in place of cold, having various temperatures for various kinds of steel. For instance, for springs, the steel must not be made more than red-hot, and tempered in water heated to 150° F. (65½° C.). Low spring steel containing 0·002 to 0·004 of carbon, when made red-hot and plunged into boiling water, has its tenacity and elasticity increased without its softness being altered. The colder the water, the more coarsely crystalline is the fracture, and by using hot water the fracture becomes more finely granulated in proportion to the temperature. By experiment it has been demonstrated that red-hot steel plunged into water at a temperature of 35° F. (2° C.) will be as brittle as glass, but when plunged into water at 212° F. (100° C.), it will be annealed and toughened. Water is not essential in the process of tempering. The only necessary condition is that of temperature, and other bodies than water may be used for contributing the right degree of heat. There are various liquids which can be heated to a higher degree than that named without requiring to be kept in a close boiler; such liquids are oil, melted tallow, wax, pitch, etc. Concentrated solutions of various salts in water make its boiling-point higher. It is substances of this kind which constitute the various tempering pickles. That the chemical constituents of the matter have nothing to do with its effects, but that it is only a question of temperature, is conclusively proved by the fact that when cooled below the freezing-point of water it by no means produces a fine granulated fracture. Oils and fats do not cool off the metal as rapidly as water. The boiling-point of water is comparatively low, and the latent heat of the steam is not very great. Its evaporation therefore carries off the heat which is in the steel with great rapidity. In using oil or melted fats it is not necessary to heat them very much; oil of 100° F. (38° C.) will be equivalent in its effects to boiling water. Jewellers and watchmakers do not temper their drills in water, as this makes them so hard as to be quite brittle. They use oil instead, or they stick the hot drill into solid sealing-wax, pulling it out quickly and sticking it in a fresh place, and repeating the operation until the drill is too cold to enter. Mercury, which is a good conductor of heat, has been used to make steel very hard; by its conductive properties it cools the steel quickly, while its evaporation aids in carrying off the heat rapidly. ('Blacksmith and Wheelwright.')

Colour Tests in Tempering.—If we heat a piece of cast-steel to redness, and plunge it into clean water until its temperature is reduced to that of the water, the result will be that the steel will be hardened. The degree of the hardness will depend upon the quality of the steel, the temperature to which it was heated, and to a small degree upon the temperature of the water in which it was cooled. In any event the operation will be termed hardening. If we re-heat the steel, a softening process will accompany the increasing temperature, until upon becoming again red-hot it will assume its normal softness, and if allowed to cool in the atmosphere the effects of the first hardening will be entirely removed. If, however, after the steel is hardened, we polish one of its surfaces and slowly re-heat it, that surface will assume various colours, beginning with a pale yellow and ending in a blue with a green tinge, each colour appearing when the steel has attained a definite degree of temperature; hence by the appearance of the colours we are informed of the temperature of the steel or, in other words, how far or to what extent the re-softening has progressed. This fact is taken advantage of by the machinist to obtain in steel any required degree of hardness less than that of the absolute hardness obtained by hardening, and is termed tempering. The temperatures at which these respective colours will appear are as follows:—

Very pale yellow .	430° F.	(221° C.)
Straw yellow . .	460° F.	(238° C.)
Brown yellow . .	490° F.	(254° C.)
Light purple . .	530° F.	(277° C.)
Dark purple . .	550° F.	(288° C.)
Clear blue . . .	570° F.	(299° C.)
Pale blue . . .	610° F.	(321° C.)
Blue tinted with green	630° F.	(332° C.)

To say, then that a piece of steel has been tempered to a straw colour, implies that it was first hardened and then reheated until the straw yellow appeared upon it, the temperature having arrived at 460° F. (238° C.), and that the reheating process was then discontinued. The presence of the straw colour, however, while evidence of temperature to which the heating took place, is no indication of the actual degree of hardness of the steel, because that depends upon the degree to which the steel was hardened before the colour test tempering was resorted to. And since the degree of the first hardening depended upon the quality of the steel, the degree to which it was heated, and the temperature of the water in which it was cooled, it follows that the above quality, heating and temperature must be uniform in all cases if uniform results are to be reached. The higher the grade of steel, the lower the temperature at which it will harden, and the harder it will be if cooled in water from a given temperature; but any degree of hardness obtained from a temperature equal to or less than the highest at which a colour would appear—that is 430° F. (221° C.)—will obviously be representable under the colour process by a colour, providing, of course, that the steel was first thoroughly hardened.

Hardening and Tempering defined. It is manifestly desirable to obtain any required degree of hardness by a single process, if possible; hence by heating a known quality of steel to a definite temperature, and quenching it in water or other liquid or mixture maintained at about an even temperature, the colour test is becoming, in some cases, dispensed with, the conditions of heating and cooling being varied to give any degree of hardness from the highest attainable down to normal softness. Another and very desirable method of hardening and tempering is to heat in a flue of some kind maintained at the required temperature over the fire, and cool either in water or a quenching or cooling liquid, and then, instead of employing the colour test, to provide a tempering bath composed of some substance that will heat, in the open air, to a temperature of about 450° F. (232° C.). Another method of tempering, which, if capable of reduction to uniformity, would be the quickest and hence most desirable of any, is to heat the steel to a definite temperature, and cool or quench it in a liquid having sufficient greasiness or other quality which acts to retard its retraction of the heat from the steel, and thus give a temper at one operation. As an example of this kind of tempering it may be mentioned that milk-and-water, mixed in proportions determined by experiment upon the steel for which it was employed, has been found to give an excellent spring temper. Nor is there any doubt that, carefully conducted, such tempering may be of the very best quality. A great deal, however, in this case depends upon the judgment of the operator, because very little variation in heating the steel or in the proportions of milk to water produces a wide variation in the degree of temper. If, on trial, the temper is too soft, the steel may be made hotter, or there may be more water added to the milk. If the steel was heated as hot as practicable without increasing the danger of burning it, more water must be added; while if the steel was made red-hot without being hot enough to cause the formation of clearly perceptible scale, the steel may be heated more.

Annealing.—(*a*) There are many ways of annealing steel: e.g. heating it to redness in the open or hollow fire, and then burying it in lime, in sand, in cast-iron borings, in dry sawdust, and by packing in carbon in an iron box and heating the whole to redness. This last process is the most effectual, provided the steel is not heated to excess. A layer of coarsely powdered wood charcoal is placed at the bottom of the box, then a layer of the steel, and so on until the box is nearly full, finishing with charcoal. The lid is luted with clay or loam; the whole is then placed in a furnace or hollow fire, and gradually heated to redness. Overheating is hurtful. It is seldom necessary to keep up the heat beyond the time when the contents of the box are uniformly heated, unless the steel should contain particles of hard impure iron, when it would be necessary to keep up the heat for several hours. When the whole has arrived at the proper temperature, the box is withdrawn from the fire and buried in hot or cold ashes to become quite cool, or left in the fire, and the fire allowed to cool down. The steel should be protected from air until it becomes cool, when it is taken out of the box, and is ready for the fitting or turning room. It is then very soft, and free from those hard bright spots which workmen call "pins." The surface of the steel will be as free from oxidation as before it was heated, and the greater portion of the charcoal will remain unconsumed, and can be used again. This mode of annealing prevents the steel from losing its quality; but it absorbs a small quantity of carbon, which is favourable to the hardening process. Animal charcoal is sometimes used.

If time will not admit of a piece of steel being softened in a box with charcoal powder, it may be heated to cherry-redness in an open fire, then drawn out of the fire, and allowed to cool till the redness is not visible by daylight, but can be seen in a dark place, then plunged at this heat into cold water, and allowed to remain in the water until it becomes quite cool. When taken out of the water, it will be more uniform in temper than when it left the forge. This is a very expeditious way of annealing; but the steel will not be quite so soft as if it were enclosed in the iron box in contact with charcoal powder. Steel required to be annealed in such large quantities as to make it inconvenient, or the expense of enclosing it in boxes too great, may be heated in a charcoal fire completely enveloped and protected from the air. After the steel is heated to the proper temperature, the fire and the steel may be covered with pieces of plate iron, the whole then covered with cinder ashes, and the fire allowed to go out of its own accord. It will thus be protected until it is cold. Charcoal, especially when used as fuel in the open fire, is consumed with rapidity, and therefore very expensive. A cinder fire is less expensive; it is not so pure as charcoal, but purer than coal, and affords a very moderate heat. When the steel is at the proper heat it is taken out of the cinder fire and placed in an iron box containing coarsely powdered charcoal, which must completely envelop the steel; the box is covered up and luted with clay or loam, in order to exclude the air and preserve the charcoal for future use.

Cast-iron may be annealed in a similar manner. In the state it leaves the moulds it is always surrounded with a crust or coating, sometimes so hard that the best file will make no impression upon it, while the interior of the casting is soft and manageable. This hard crust is generally removed either by chipping with the cold chisel, or by grinding on a large grinding-stone turned by machinery. But when the shape of the casting is such that this crust cannot conveniently be so removed, annealing is the most economical process, as it makes the whole casting soft and much easier to work, but not deprive it of its natural character. The heat requires to be kept up much longer than for steel, and the iron needs solid supports to keep it from bending or breaking by the heat. When annealed it is more uniform in temper, consequently less liable to alter its figure by subsequent partial exposure to moderate heat. The outside is always somewhat harder than the inside, unless such processes be adopted as will extract the carbon from the former; but these processes deprive it of its natural character and make it in the condition of malleable iron, but without the fibre which is due to the hammering and rolling. Cast-iron cutlery is enclosed in boxes, and cemented with some substance containing oxygen, such as poor iron ores free from sulphur, scales from the smith's anvil, and various other absorbents of carbon. The boxes are luted as when annealing steel or case-hardening iron: they are afterwards placed in suitable furnaces, and the cast articles are kept in a state little short of fusion for 2 or 3 days, when they are found to possess considerable malleability, and can be readily bent and slightly forged. (Ede's 'Management of Steel.')

(*b*) In annealing tool steel in small lots in an ordinary blacksmith's fire, my method is to cut the steel to the desired length and heat it evenly and thoroughly to a good red heat, but not hot enough to scale. The work is best done in a hollow or mound fire, which is made by packing wet coal on the fire until a good mound is formed, when an opening is made in front, of a size large enough to admit the steel that is to be annealed. Such a fire is practically an oven.

When the coal is well charred the steel is put in and heated up slowly and thoroughly, care being taken that it shall not get above a good red. The steel is then put in a bed of ground wood-charcoal in a box to cool. My annealing box is made of cast-iron, 4 ft. long, 15 in. wide, and 12 in. deep. This is filled about two-thirds full of the charcoal dust. If quite small pieces are to be annealed, I heat them in an iron pipe 2½ in. diameter, plugged at one end, the pieces being packed in with charcoal and all heated together. When thoroughly heated, the pipe, with its contents, is placed in the charcoal dust in the box to cool.

Small pieces, if placed in cold charcoal, without the protection of the pipe, will come out imperfectly annealed and with more or less hard spots. I have used lime to some extent for cooling in, but do not like it as well as coal-dust, as it does not retain the heat as long. Some persons complain that cooling in lime puts hard "pins" and "streaks" in steel; but I do not think any trouble will arise on this score if the piece be large enough to heat up the lime. If, however, the piece is rather small it is better to heat it packed in a pipe, and cool as above mentioned. I have had very good results from this mode of treatment.

Miscellaneous Receipts.—The following recipes for hardening, softening, tempering and annealing are classified as nearly as possible according to the character of the article operated upon.

Cutlery, Razors, Saws, etc.—Razors and penknives are too frequently hardened without the removal of the scale arising from the forging. *This practice, which is never done with the best works, cannot be too much deprecated.* The blades are heated in a coke or charcoal fire, and dipped in the water obliquely. In tempering razors, they are laid on their backs upon a clean fire, about half a dozen together, and they are removed one at a time, when the edges, which are as yet thick, come down to a pale straw colour. Should the backs accidentally get heated beyond the straw-colour, the blades are cooled in water, but not otherwise. Penblades are tempered a dozen or two at a time, on a plate of iron or copper, about 12 in. long, 3 or 4 in. wide, and about a ¼ of an in. thick. The blades are arranged close together on their backs, and lean at an angle against each other. As they come down to the temper, they are picked out with small pliers and thrown into water, if necessary; other blades are then thrust forward from the cooler parts of the plate to take their place. Axes, adzes, cold chisels, and other edge tools, in which total bulk is considerable compared with the part to be hardened, are only partially dipped; they are afterwards let down by the heat of the remainder of the tool; and, when the colour indicative of the temper is attained, they are entirely quenched. With the view of removing the loose scales or oxidation acquired in the fire, some workmen rub the object hastily in dry salt before plunging them in the water, in order to give them a cleaner and brighter face.

Oil, or resinous mixtures of oil, tallow, wax, and rosin, are used for many thin and elastic objects, such as needles, fishhooks, steel-pens and springs, which require a milder degree of hardness than is given by water. Gunlock springs are sometimes *fried in oil* for a considerable time over a fire, in an iron tray ; the thick parts are then sure to be sufficiently reduced, and the thin parts do not become the more softened from the continuance of the blazing heat.

Saws and springs are generally hardened in various compositions of oil, suet, wax, etc. The saws are heated in long furnaces, and then immersed horizontally and edgeways into a long trough containing the composition. Part of the composition is wiped off the saws with a piece of leather, when they are removed from the trough, and heated one by one, until the grease inflames. This is called "*blazing off.*" The composition used by a large saw manufacturer is 2 lb. suet and ¼ lb. of beeswax, to every gallon of whale oil ; these are boiled together and will serve for thin works and most kinds of steel. The addition of black resin, about 1 lb. to each gallon, makes it serve for thicker pieces, and for those it refused to harden before ; but resin should be added with judgment, or the works will become too hard and brittle.

Cutters.—(1) If for a cold set, have it very stiff; round the corners slightly. The principle in tempering cutting tools for striking on is to avoid the "hard line" : the temper should die away gradually. The system adopted with sucess is as follows :—1st. Always heat the tool a long way up. 2nd. Never dip in absolutely cold water. 3rd. Dip deep, and move the tool slightly up and down in the water. Half-round tools are most liable to fly ; get it hot right up to head, and if there is not heat enough left to draw the temper in itself, get lump of white-hot iron to get the head on, or put head in fire.

(2) Quench in soft clay instead of water ; it should be pretty stiff. Some things more susceptible to warping are done in this way. Plunge in sharp and straight.

(3) Get cutters just red-hot, and throw them into luke-warm water edgeways ; they must be left in the water till all is cold, otherwise they will crack. If you cannot wait till the water gets cold, gently pour in cold water. If any warp, they can be put straight with a few blows over some hollow place when they are hot. In tempering them, do not trouble whether the teeth are sharp or round at bottom. By the above plan you will go over a large quantity in a very short time ; only be sure not to take them from the water till all is cold.

(4) Make the cutter of as low a red heat as it will harden at, and quench (flatways) in water slightly warmed. In forming the teeth, make the bottom round, not sharp, as they are more liable to crack at those points,

(5) Take a bucketful of clean water, and add 1 gill of vitriol ; stir up well, and bottle for use. This will last for years if kept corked up : when using it, put your cutter on the top of a piece of sheet iron, and when properly red drop into liquor. This, when taken out, will be as hard as flint. Blaze, and let down to a purple for cast-steel. This has never failed in one case out of fifty.

(6) Drive a lump of iron into the hole in the centre, and after heating cutter and iron to the requisite redness for hardening, plunge both into the water. The heat in the iron keeps the steel round the hole hot sufficiently long to enable the steel to contract equally.

(7) "Carbonize" the fire by burning a lot of old scraps of leather, take a flat plate of iron, urge the bellows slowly to make this plate red-hot. Then lay upon the cutter, or saws, with another plate over this to throw the heat and carbon down until you can

see it a pale red heat. Then take it off and slip it edgeway into about 1 qt. or more of oil. Do not use water. After being in about ½ minute take it out and place it between two pieces of very flat hard wood, and squeeze it very tight in a vice; it will now be ready for use.

(8) Very gradually heat over a clear coke fire to a dull cherry-red, and then slide it, as it were, into the water quickly at an angle of 10° or 15°. Use water with the chill just taken off.

(9) Adopt some method of preventing the water having access to the hole and to the central part of the cutter when quenching. A good way would be to provide a rod of iron, say ⅜ to ½ in. diameter, screwed (tapped) for a distance of 2 in. at the end. First, put on a nut, then a broad washer, say 1½ in., or even more, in diameter: next your soft cutter; then another broad washer, and, lastly, a nut over that. Take plenty of time about heating the work, and have a good lot of fire ready blown-up; that is, avoid blowing the fire hot while the work is in it; but, on the contrary, have the fire already prepared, and let the work "soak," turning it over and over, till it is of an even temperature all over. If you prefer it, the piece of screwed rod need only be long enough to carry the work and the two nuts and washers, and you will then handle the whole with the tongs. Dip edgeways, and there will be no fear of flying in hardening. An incidental advantage is that it matters little if the cutter contracts in hardening, as sometimes is the case, for you can correct the hole by scraping or filing at your pleasure. Always avoid leaving much substance towards the middle of your cutters; 1/16 to ⅛ in. thick in the central web, held between a flat shoulder on one side and a well-fitted washer and set-screw on the other, is sufficient for cutters up to 3 in. or 4 in. diameter for milling wrought-iron. If you leave them thick, they will go to pieces, unless you specially provide against the water reaching them. Use a charcoal fire if you can get one.

(10) For cutters 3 in. and upwards in diameter, the hardening process is a hazardous one, and causes some anxiety. In the first place, the lowest temperature at which the steel will harden should be ascertained. If at a blood-red heat, so much the better. The cutter, when roughed out to near the size before the finishing cut is taken off, should be well annealed. This precaution is too often neglected—whether for large taps, lathe mandrels, or cutters, it will be found, after the annealing, that a degree of warpage has taken place, showing that the steel, though soft, was nevertheless in a state of tension, and this preliminary annealing greatly lessens the tendency to crack in the hardening. For a cutter of 3 in. in diameter, a large clear fire of cinders should be used, great care being taken to heat the work uniformly. The cutter should be smeared over with a paste of soap and leather charcoal. This causes the finished cutting edges to come out bright and quite hard, after the quenching. Before hardening taps and drills, rub a piece of soap over them before heating, as no scale is then formed, and they come out clean after quenching. For large cutters, etc., in order to lessen the risk of cracking during the quenching, pour oil over the water to the thickness of a card.

Files.—(1) The point of a file, being thinner than the middle, is liable to become hot sooner, and attain a purple colour before the thickest part shows any degree of heat; to prevent which the heat must be applied gradually, by shifting the file backwards and forwards in front of (not over, because the smoke will colour it) a bright fire or furnace door, so as to keep the thickness. A piece of sheet-iron should be hung in front just above the file, to keep the glare of the fire from the operator's eyes, and by comparison from time to time with a new file (which should be at hand) he will be enabled to judge of the progress of the operation, and regulate the heat until the desired colour is obtained, when the file must be immediately plunged into water. Pale straw colour is low enough for most files, but no file should be brought lower than deep straw. (2) Cover with oil, and hold over the fire until the oil blazes, and as soon as the flame runs all over the file, plunge it in the water; or put in a moderate hot oven for ½ hour if large file; but if small, the former is better. (3) A mixture of tallow, hog's lard, and arsenic makes an excellent mixture for hardening files. The oil becomes thicker after being in use a week or two, and fresh oil is added each week, the thickest being taken out for giving a bright black to iron or steel.

Gravers.—Heat in charcoal dust (not too hot), and plunge into a box of wet yellow soap. This renders the end of the graver very hard and very tough.

Hammers.—(1) Drive piece of iron rod in eye to hold head by. Make full red-hot, lay rod on edge of slack trough, harden the largest end, then turn small end in water, watch for temper in face, then the same to small end. When you have both ends right, keep turning them round in water until middle is about black-hot, then cool off. Do not dip deep. The colour will vary with different qualities of steel, and can only be determined by trial. With ordinary steel, from brown to blue will be about the thing. (2) A hammer weighing 1 lb. should be allowed 15 seconds to cool down before plunging, and then you will require nothing but clear water. Hammers weighing 2 lb., 3 lb., or 4 lb., should be allowed 30 seconds.

High-Speed Steels.—It has been my privilege, said Mr. Edward Ford, C., M. and St. P. Ry., to the National R. R. Master Blacksmith Association recently, to handle several kinds of air-hardening steel, and, on the whole, we have been very successful. There are two men whom it is very essential to take into consideration to get good tools and correct reports of the work done by those tools, and they are the tool-dresser and the machinist who uses the tools. The tool-dresser should heat the steel thoroughly, and not too fast, to a high lemon heat while shaping the tool, and when done he should lay it aside for a few minutes to cool and to relieve the strains, then heat it up to a high heat, or until the scales are seen rising, and then place it under a compressed-air blast, being sure there is no moisture in the air-pipes; allow the blast to strike the tool at about 1 in. from the point. Always have the blast blowing towards the point of the tool, and keep the point of the tool free from scales with a file, so that the cold air will always play right on the point of the tool; but where there is no compressed air, you will find a good substitute in the blast pipe.

Lathe Mandrel.—(1) Have the water lukewarm, and a little soapsuds in it. Bring the mandrel to a cherry-red, catch by the end in tongs, and be sure to dip slowly and vertically to the bottom of the tub. If moved sideways, it will camber. (2) The risk of cracking steel when hardening is much reduced by surrounding the article, when in the fire, by shreds of leather, bone, etc., or by covering it with prussiate of potash as soon as it gets to a dull red heat; then it may be heated to the proper temperature for hardening. It is a very difficult thing to prevent the spindle from being bent and distorted. If hardened in water, it is almost sure to "warp," and, if the mandrel is a large one, it is not easy to harden it in oil. If it is of moderate size, heat it as above, with leather, etc., and at a good red heat; immerse it vertically in a mixture of oil and tallow.

Mill Bills.—(1) Get the point of the bill red-hot, put it on the ground to cool, try it with a saw file. If you cannot cut it, it is Mushet's steel. Treat as follows:—Get bright red, work out a little at a time. On no account hammer when getting cool, or they get full of little cracks. Better keep heating as often as they lose their red appearance. The whole secret in working this steel lies in not hitting it unless red-hot. After you have got them to the right shape, which should be about ⅛ in. thick at 1 in. from the end, get them bright red, and put them carefully on the ground to cool. This is all the tempering the steel requires. When cold, grind to an edge. If common cast-steel, you do not want to know anything about secrets or chemicals. All you have to do is to work it out at a dull red heat, hit it flatways when cooling as much as you like, but not edgeways; file or grind to an edge, get red-hot ¾ in. from the end, dip or cool in water with the chill taken off, grind bright, hold over a piece of red-hot iron till of a blue colour. (2) Salt, ½ cup; saltpetre, ½ oz.; pulverised alum, 1 teaspoonful; soft water, 1 gal. Do not heat above a cherry-red, nor draw to temper. (3) Put the body of the tool in the fire, leaving the two thin ends uncovered till the middle is red-hot. As soon as the middle is red-hot, pull back, and let the thin end just get a dull red heat. It must now be hammered edgeways first, and flatways last of all. It is best to hammer it on the flat part of the anvil, as drawing steel on the edge of the anvil, although a great deal quicker, makes it short in the grain, and always causes the tool to break in the thinnest place. Serve the other end the same, only repeat as soon as it loses its dull red colour. The lighter the blows in working steel, the tougher it is. The point should be quite as thin as a fitter's chipping chisel, only a little longer, then they will not require doing up so often. When the ends are drawn out, the middle will have lost its red heat. The ends can now be filed a little. To temper them heat them in the flame of the fire, using great care. When a very dull red heat, cool in rain-water, with the chill taken off, about ¾ in. from the end, and let down to a blue; if it should be too brittle, a little lower. Serve the other end the same. Cool all over. Grind the edge rather blunt, and for the first few blows hit as lightly as possible. A little soapsuds or oil could be poured on the water, but water is the best. The secret is in working it at as low heat as possible, only keep on repeating very often, and to hit it edgeways as little as possible, but flatways as much as you like.

Mill Picks and Chisels.—(*a*) Heat the bill to a blood-red heat, and then hammer it till nearly cold; again heat it to a blood-red, and quench as quick as possible in 3 gal. of water, in which is dissolved 2 oz. of oil of vitriol, 2 oz. of soda, and ½ oz. of saltpetre; or, 2 oz. of sal ammoniac, 2 oz. spirit of nitre, 1 oz. oil of vitriol. The bill to remain in the liquor until it is cold.

(*b*) 1 oz. white arsenic, 1 oz. spirits of salts, 1 oz. sal ammoniac, dissolved in 4 gal. of spring water, and kept in a tube or iron phial for use. Heat the tool to a blood-red heat, then quench it in this mixture, draw it gently over the clean fire till the spittle flashes off it, then let it cool.

(*c*) To 3 gal. of water add 3 oz. of spirit of nitre, 3 oz. of spirits of hartshorn, 3 oz. of white vitriol, 3 oz. of sal ammoniac, 3 oz. of alum, 6 oz. of salt, with a double handful of hoof parings; the steel to be heated a dark cherry-red. Used to temper chisels for cutting French burr stones.

Mining Picks.—In the first place, a good charcoal fire is necessary; next, good steel, and then a good light hammer with a smooth face anvil. A pick should never be "upset," or hammered endwise, nor raised above a full red heat. The steel should be, moreover, heated as quickly as possible, as long exposure to heat—even if the heat is not in excess—injures its textures. Many blacksmiths find great difficulty in tempering picks, because they do not choose good steel. After being heated, the pick must be worked with care, special pains being taken, in drawing it out, to hammer on all sides alike, in one place as much as another, and on one side as much as another. When ready for hardening, it should be heated in the blaze of a charcoal fire until red-hot, and then plunged into cold rain water, and kept there until it is nearly cold; but if kept too long in the water, or until it is quite cold, the corners are liable to fall off. Some blacksmiths use salt water; no salts of any kind should exist in the water, but the water should be cold; if the water is warm, and a little ice should be thrown in to chill it, the tempering will be all the better. Pure soft water for hardening will make a tougher pick, and one less liable to crack at the edges, than where salt water is used. An old miner who always sharpened the picks at the claim, and was quite expert at it, used to hold the pick end in the water exactly until a certain shade of colour appeared. Then he did not consider it properly tempered until the point was inserted in the ground and allowed to gradually cool. The last hammering of a pick should always be given on the flat sides, across close to the edges, and then up each side about an inch. By doing so, the corners will be less liable to crack off.

Saws.—(1) After toothing comes hardening, the toothed plates being heated to a light cherry-red, and then plunged into a bath composed of whale-oil, tallow, rosin and beeswax. The plates, after hardening, should be as brittle as glass. They are covered with scale, grease and dirt, which is removed by scraping and scouring with sawdust. They come out buckled, and require to be flattened. This is done between heated dies brought together by hydraulic pressure. The dies are circular in form, horizontal in position, and about 5 to 6 ft. in diameter. They are enclosed in a furnace with an adjustable blast, and are revolved, to keep the temperature even. The proper colour for hand-saws is a blue, corresponding to spring temper.

(2) Dr. Hartmann recommends the addition of about 1 lb. rosin to the usual hardening mixture, consisting of 4¾ qt. train-oil, 2 lb. beef tallow, and ¼ lb. beeswax, as rendering it suitable for hardening some articles that do not harden sufficiently without it, although the proper amount of rosin can only be determined by experience, since excess of it may render the article too hard and brittle. After use for some months, the mass loses its hardening power, and the trough must be thoroughly cleaned of it before fresh mixture is placed in it. He also recommends another mass, consisting of 95 qt. spermaceti oil, 20 lb. melted tallow, 4½ qt. neat's-foot oil, 1 lb. pitch, and 3 lb. rosin. The pitch and rosin are melted together, the other ingredients added, and the mass is heated in an iron vessel until all the moisture is expelled, and the heated mass ignites from a burning splinter held upon it; the flame is thereupon immediately extinguished by means of a tightly-fitting cover. In employing either mixture for saw-blades, these, after being heated in a suitable furnace, are placed vertically in long troughs filled with the mixture, with the toothed edge, or that intended for the teeth, down, and as soon as they are sufficiently cooled, they are removed and wiped with leather until but a film of grease remains upon them, and are then placed flat over a coke fire until the coating ignites, by the burning of which their brittleness is diminished, and the requisite elasticity imparted. If they are to be very hard, but a small portion of the coating is allowed to burn off; but if softer, it may be allowed to burn until it goes out.

Springs.—(1) Harden right out, and then temper by flaring off in oil. If they are flat springs, a good way to harden them would be to get them red hot, and lay them on a flat iron surface, covered with water, quickly bringing another piece of flat iron (of about 7 lb. in weight) down on top of it. This will prevent them warping. If they are curved or bent, this cannot be done. If bent, put them into water (or oil, which is better than water for small springs) edgewise. To produce a nice spring temper, place them in a shallow sheet-iron dish, cover them with lard oil (this is important—mineral oils will not do), and hold them over the gas with a Bunsen flame until the whole of the oil has burned or flared away; then turn them out, and let them cool of themselves.

(2) First harden right out by making red-hot, and cooling in water; then, to temper, have a bright, clear, arched fire, and move the spring to and fro in it until it is hot enough to scorch a stick or make sparks fly off a stick when rubbed along it, care being taken that it will do this all along the spring, and yet not be hot enough to set fire to the stick; then let it cool of itself.

(3) Whale-oil is used for tempering springs, which are first heated in the lead bath, then plunged in the oil, and blazed off in the fire.

(4) For long springs get a piece of 1-in. wrought-iron gas-pipe, put your spring inside, place the pipe in furnace. When hot enough get hold of pipe with tongs, tip the pipe up over tank with oil or other tempering fluid in,, and the spring will slip out into tank. If you have 2 or 3 pipes, you will temper over a gross per hour.

(5) Get a piece of spring steel about the size of spring wanted; when forged and filed to tilt, make it warm-red, immerse in spring water (a little cow-dung improves it, mixed well with the water before using it). Dry the spring, then tie a piece of wire fast to the spring in any form, so as to hold it. Dip in clean tallow or oil, put it on the fire till all the grease is burnt off, and swing round and round as swift as you can till cold.

Taps and Dies.—(1) Rose says taps should be heated for hardening in charcoal fire, slowly to a cherry-red, and then dipped perpendicularly into clean water. The water should be made sufficiently warm to feel pleasant to the hand; for, if the water has not the cold chill taken off it, the taps are apt to crack along the flutes. The tap should be lowered perpendicularly in the water, even after it has disappeared below the surface; but in no case should it be moved sideways, or it will warp. It should not be taken out of the water until quite cold, or it will crack after it is taken from the water and during the cooling process. After the tap is hardened, it should be brightened along the flutes and on the plain part, and then lowered as follows:—A piece of tube, about half the length of the tap, and of about twice or three times its diameter, and having its thickness about the same, if possible, as the diameter of the tap, should be heated in the fire to an even cherry-redness, and then taken from the fire and placed in such a position that it is open to clear daylight, and not affected by the rays of light from the fire. The tap should be held in a pair of tongs, whose jaws have been well warmed; and a small piece of metal should be interposed between the jaws of the tongs and the sides of the square of the wrench-end of the tap, so that the tongs may not obstruct the square of the tap from receiving the heat from the tube. The tap and tongs should then be passed through the heated tube, so that the square end of the tap and the tongs only will be inside the tube. The tap should be slowly revolved while in this position, and when the tap has at that end become slightly heated, but not enough to draw the colour, the shank and threaded part of the tap should be slowly passed endways back and forth, and, while slowly revolving, through the centre of the tube, until the colour appears; if it assumes an even hue all over, proceed until a brown colour appears, then withdraw the tap from the tube, and quench it perpendicularly in warm water. If, however, the colour does not appear so quickly in any particular part, hold that part on the tube a little the longest, and if either end lowers too rapidly, cool it by a slight application of oil. The square end of the tap, on which the wrench fits, may be lowered to a deeper colour—as may also the shank of the tap—than the threaded part, which will leave them stronger and less liable to twist or break. By using the size of the tube here recommended it will be found that the tempering process will be performed, and the colours appear very slowly, so that there will be ample time to judge when the precise requisite degree of hardness has been reached. This plan is far superior to tempering in heated sand. Very long taps may be greased and heated preparatory to being hardened in molten lead—the object being to heat the outside of the tap evenly all over to a red heat, so rapidly that the inside metal of the tap is comparatively cool; hence, when the tap is hardened the outside only is hardened; and if the tap warps in the hardening, it can, after being tempered, be straightened—the soft metal of the centre of tap preventing it from breaking in the straightening, which should be performed with a leaden hammer and with the tap resting upon lead.

(2) Take the chill off the water, then get them to a cherry-red heat. Plunge the taps in on their ends. After they are cold, clean with a bit of stone or emery-cloth; then warm them till the spittle fries on them. Put some clean tallow on, then hold them over a clear fire till a light chestnut brown.

(3) The great difficulty in hardening tools is principally their liability to twist or get out of truth; secondly, cracking (especially if large) after hardening; thirdly, getting the right temper. First, carefully select your steel; let it be of the best cast, with a medium grain (a fine-grained steel will break when much less force is applied than a coarser-grained, and although it will take a keener edge, it will not resist the strain required by a tap or rimer). Next centre it, and turn off the scale and soften. The object of softening after the scale is removed is to make the grain of the steel equal throughout; if it be softened with the scale on, it will generally cast. To soften, enclose the articles in a piece of gas-tube, filling up with wrought-iron turnings, and plugging the ends with clay, making the whole red-hot and allowing it to cool very slowly—*i.e.* leaving it in hot ashes all night. This method makes the steel very soft, and equalizes the grain. After softening, turn up the work, taking care not to bend or straighten it, should it have cast, as it probably will in the process of softening. The reason for this is, that if the steel be bent or hammered, the grain will be closer in one place than another, and heat has a great tendency to bring it back to its original position. The next thing after finishing your tool is to harden it: first, slightly heat it over a gas or other flame, and rub it all over with a mixture of Castile soap and lampblack. This is to prevent the edges from being burnt. The next is to get a thick iron pipe (2 in. diameter and ¾ in. bore). This is well filled up with taps or rimers and charcoal dust, the ends being closed with clay as before; this is placed in the furnace and occasionally turned, until it is one uniform heat of cherry-red, or on the outside a trifle hotter. It is then carefully removed from the fire, one end of the clay is knocked off, and the contents are allowed to drop perpendicularly into a solution of water, chloride of sodium, and nitrate of iron; this solution is kept at a temperature of 60° F. (15½° C.). The articles hardened should remain at least ¼ hour before being removed. This method of hardening may be summed up thus: make the steel of one grain throughout, prevent it from oxidizing whilst being heated, allow every part to heat at the same time, avoid bending while hot, and lastly, restore if possible by replacing the loss of carbon caused by heating.

Tools generally. — (1) **Softening.** (*a*) Heat your steel to dull redness, hold it in some dark or shady nook or corner until you can just see the least possible tinge of redness, then cool immediately in water at the ordinary temperature, and you will be able to file or turn it with very little difficulty.

There are times when the delay of the ordinary process is extremely inconvenient—as in the filing of turning tools of a particular shape, re-annealing steel when the skin is taken off, etc., and then this mode answers admirably. (*b*) Make the steel red-hot, then put it in a heap of dry sawdust till cold, when it will be found to be quite soft. (*c*) Place a quantity of newly-burnt lime in a damp place, where it will fall in the form of flour; put it in an iron box. Heat the articles to dull red, clean off all scale, put in lime, and completely cover with lime; cover box over with iron lid, and leave until cold. The more lime and larger the box the better. Keep air-tight if possible.

(2) After being tempered, the volume of the tool is slightly increased, and consequently its specific gravity is decreased. As the expansion or increase of volume is so very slight, it is quite immaterial which is plunged in the liquid first; however, every moment the edge is kept out it is cooling, and the tempering may be rendered defective thereby. Mercury tempers the hardest, then water, then salt water, then oil of various kinds—as whale-oil. As oil cools the metal more slowly, it is not tempered so hard, but the tenacity is increased.

(3) It is said that the engravers and watchmakers of Germany harden their tools in sealing-wax. The tool is heated to whiteness and plunged into the wax, withdrawn after an instant and plunged in again, the process being repeated until the steel is too cold to enter the wax. The steel is said to become, after this process, almost as hard as the diamond, and when touched with a little oil or turpentine, the tools are excellent for engraving, and for piercing the hardest metals.

(4) Tools deeply dipped, and with the temperature let down slowly, are the best tempered. For instance, a carpenter's chisel may be heated in a tube (covered with coke until the whole is at a red heat) until it is at a heat slightly more than blood-red; then lower vertically down to the bottom of a pailful of tepid water; when cold, take it out and polish it. Get a bolster, or large nut, heat it to whiteness, and traverse the chisel through and back until the surface has an orange or gold colour; cool out. Taps, dies, half-circular cutters, etc., so tempered, stand wear and tear much the best.

(5) The forging and tempering of iron or steel can be greatly enhanced, according to Blass, by dipping the metal, in whatever form, in fused salt. This dipping in salt is also well adapted for annealing steel without the oxidation of the surface. If the metal be rusted, it must be allowed to remain some time in the bath. Borax can with good effect be mixed with the salt. Metal "purified" by such an immersion is very susceptible to galvanic dispositions, and can easily be coated with copper, zinc, tin, nickel, silver, etc. For iron in the spongy or powdered state, as obtained from the reduction of the ores, the salt bath is especially adapted, for it augments the combination of the particles by making their surfaces free from impurities. To prepare the bath for an application as here proposed, the salt must be fused in a puddling furnace, and the iron sponge, with the addition of a flux, be added in small quantities, so as not to vitrify the salt. The iron is left in the furnace till the flux has combined with all the impurities, and formed a slag, whereupon the iron is taken out and forged together. While the iron is in the furnace, it should be constantly covered with the salt, so that oxidation be prevented. For the hardening of iron, the salt is fused in a convenient vessel and the object immersed, and from time to time a small quantity of potash ferrocyanide is added—1 lb. or 2 lb. per 100 lb. of iron. The articles, according to their thickness, are permitted to remain 5 to 30 min. in this bath, and are then plunged in water containing, in 100 parts, 1 of hydrochloric acid, 5 of wine vinegar, and 1 of salt. If the objects are to have a silver lustre, they should

be immersed for a few minutes in a mixture of 3 parts wine vinegar and 1 of hydrochloric acid.

(6) Steel punches, or other small implements, particularly engraved dies, when, by accidental exposure to too great heat, they have become spoiled, or, as the blacksmith says, burned, may be restored by the following mixture : 2 oz. bichromate of potash, 1 oz. pure nitre, 1 oz. gum-aloes, 1 oz. gum-arabic, and 2 oz. rosin. The whole having been well powdered and mixed, the piece of steel is heated to low redness, and the powder sprinkled over it. It is then heated again to low redness, and cooled. This makes the piece very hard again. The amount of nitre may be doubled, and that of the rosin taken 10 times greater, to produce a higher temper.

(7) In tempering a tool for boring cylinders, turning rolls, or any large pieces of cast-iron, let it be as hard as water will make it, taking care not to heat it more than to cherry-red. In the second heating, after the tool is hardened, the first perceptible tint is a light straw-colour, which makes its appearance when the heat reaches 430° F. (221° C.). This gives the metal a maximum of hardness, with a certain amount of elasticity, fitting it for lancets, razors, and surgical instruments. At 470° F. (243° C.) a full yellow is produced, which is the temper employed for penknives, scalpels, and fine cutlery. The temperature of 490° F. (254° C.) gives a brownish-orange, suitable for shears and chisels used for cutting iron. At 510° F. (266° C.) the brownish-yellow becomes flecked with purple, the tint for pocket-knives 520° F. (271° C.) gives a bluish purple, fit for table cutlery ; while the different shades of blue from 530° to 570° F. (277°-299° C.) indicate a temper proper for watch-springs, sword-blades, saws, and instruments requiring great elasticity. Beyond this temperature the metal becomes too soft to be used for cutting instruments. The temper greatly depends on the quantity of carbon that is in the steel. This the practical man soon finds out, and he tempers or draws down the tool accordingly. In Switzerland, razors, pocket-knives, etc., made from English cast-steel, are tempered by immersing the blades at a dark cherry-red into a bath composed of 4 parts finely powdered yellow rosin, 2 of fish-oil, to which is added, in a very hot state, 1 of melted tallow, and allowing them to cool perfectly ; after which they are heated without wiping them, and hardened in water in the ordinary way. The blades hardened by this process are found to be more uniformly tempered than by any other, making it possible to produce an exceedingly fine cutting edge.

(8) By melting together about 1 gal. spermaceti oil, 2 lb. tallow, and ¼ lb. wax, a mixture is obtained very convenient for tempering any kind of steel articles of small size. Adding 1 lb. rosin, it is used for the tempering of larger articles. The addition of rosin must be made with care, for an excess of this material renders the steel too hard and brittle. After several months' use the mass loses its energy ; it must then be wholly renewed, taking care to thoroughly cleanse the bottom of the tub which contained it. Another mixture, of which practice likewise has proved the efficacy, consists of 20 gal. spermaceti oil, 20 lb. tallow, 10 gal. ox-foot oil, 1 lb. pitch, and 3 lb. rosin. The pitch and rosin are melted together, then the three other materials are successively added, and the whole is heated in an iron pot till all the water is evaporated. This is ascertained when the mass takes fire at the approach of a burning chip of wood ; the flame is put out by hermetically shutting the pot with a cover. The tempering is effected in both cases as follows : Saw-blades, for instance, are heated in special ovens, and when they have reached the temperature, they are dipped in the mass contained in tubs arranged side by side. For a continuous manufacture a certain number of tubs are used, so as to allow the mass time for cooling during the progress of the operation. As

soon as the blade is cooled it is withdrawn from the bath and cleaned with a piece of leather, so that there remains still on it a thin layer of grease. It is then passed over a coke fire till the grease catches fire and burns with a clear smoke. In this way the blade acquires elasticity. If it is desired very hard, a part only of the grease is allowed to be burnt; the more softness is desired the more the burning is completed. For springs, the flame is left to burn itself out. If the objects are of various forms and sizes, the burning is repeated on the several parts till all are deemed equally tempered. The blades are finished by hammering and heating them again on a clear coke fire till they return to a straw-yellow hue. The coloration is then taken away by washing in dilute hydrochloric acid, and afterwards in plenty of water.

(9) Some mechanics attach much importance to a hardening pickle, but probably failure comes as often by injury in heating the article as by hardening and tempering. An evenly-distributed heat of the proper temperature is absolutely requisite to success, and this it is not always possible to assure by heating in an open fire. One portion of the article is liable to be overheated, while another portion is underheated; judging of the amount of heat by colour is not always to be trusted; a dark corner or a cloudy day changes the conditions from a light shop and a sunny day sufficiently to make a great and telling difference in the amount of heat judged by sight.

A perfectly reliable method of heating for hardening is by means of the lead bath. It is an easy matter to keep in the shop a crucible or iron pot of lead to be used as occasion demands. The article to be heated for hardening will not suffer when in the lead bath, even if not closely watched, as is necessary at the open fire; the melted lead cannot pass to a degree of heat injurious to the steel. But one condition must be strictly observed—the lead must be pure and clean; it is best to buy the mercantile pig for this purpose.

In order to harden well, it is necessary to heat the article through and through. If the piece is of unusual thickness, as a tap or reamer of 3 in. or more in diameter, it is better to drill a hole through it from end to end, so that the heating can be even and the hardening be equal. A tap of 4 in. diameter broke squarely across in the hardening. It was of solid steel. The drilling of an inch hole from end to end was practised, and a large number of the same size taps were hardened without a failure. ('Scient. Amer.')

(10) Firstly, the steel must only be heated to dark red, which is the temperature at which a film of soot burns off.

Secondly the heated article must be carefully protected from oxidation; hence a flame rich in carbon must be used, and the immersion be done as quickly as possible, so as not to keep it long in the air.

Thirdly, water used for hardening must be free from alkalies and lime carbonate. (Reichel, 'Zeit. f. Instrumentenkunde.')

(11) A great many different articles require to be hardened. The first will doubtless be a cutting-tool of some kind. Take, for example, a set of tools for metal-turning—say, gravers, chisels, and parting-tools. The tools having been filed up and prepared, a clear fire at a small forge will be the best means of heating them. The tools are held by the tang in a pair of small forge-tongs, and the blade must be heated slowly until it is at low redness. Care must be taken not to over-heat the steel, or its cutting properties will deteriorate, and in that case it will be perfectly useless as a cutting-tool. When the steel is made to the desired heat, it must be plunged into cold water, which will render it perfectly hard, and if it were used in this state, the point, or cutting-edge, would immediately break off. It depends a great deal upon the material that is to be turned what heat will be the best to make the tool before

dipping or plunging it; and another plan, used in some cases, is to take the extreme chill off the water. The hardening having been finished in a satisfactory way, proceed to temper it and make it fit for use. The face of the end so hardened must be cleaned either with a piece of emery-paper or on a grindstone—either will do, as long as the part to be tempered is cleaned so that the colour can be seen when it appears. Having got all the tools that are to be tempered ready, make a piece of bar-iron about ⅜ in. by 1½ in. red-hot, and on it place the tools, with the hardened end extending beyond the heated surface, and in a short time it will be easily noticed that the bright part gradually changes colour — of course, being deeper where it is nearest the iron. As soon as the cutting part gets to a straw-colour, it must be again dipped into water, to prevent its going deeper and becoming too soft for its purpose. There are also many different degrees to which cutting-tools for turning various substances should be what is termed "let down to." For example, a tool that is to be appropriated for turning steel, especially if it is not well softened, will require to be harder than one that is to be used for turning brass or gun-metal; therefore, if the latter is to be the material worked, leave the tool on the hot iron a little longer, until it becomes a darker straw-colour, or orange tint. Only practice will perfect anyone in this most useful branch of mechanics. Any workman of experience can tell in a moment what temper will be required for the many different purposes the various tools are used for. Another way, which by men of practice is generally adopted, is to heat the tool, then dip it into water as far as necessary, and let down the temper with the heat left in the other end of the tool. The colour being obtained, the whole tool is cooled in the water, and the necessity for heating the iron is dispensed with. Assuming that a quantity of small articles are made, and ready to be hardened and tempered, great care must be taken not to overheat them; the best way to avoid this will be to build a small hollow fire, and in this place an iron box, about 4 or 5 in. square, and open at the end. Make it red-hot, and on the lower side place the cutters in a row. The fire must be kept going, or the box will cool; they will soon get hot, subjected to the heat in the box. This not only makes a certainty of not burning the tools, but enables the operator to have a dozen at a time getting hot. When the whole lot are so hardened, the bar of hot iron will be again required. While this is getting hot, the faces of all the tools can be cleaned, and then placed in a row on the hot iron; and as they run down very quickly, being small, it is better to hold in the left hand a vessel of water, and with the right hand push off each tool as it assumes the required colour. By this means a number of articles may be soon effectually hardened and tempered. There are other means for effecting the same purpose. One of these is the blowpipe. Have a large piece of charcoal, in which make a hollow; there place the object to be heated, and blow the flame into the recess; it becomes a miniature oven, and all the heat of the flame is utilised. In making a spiral spring hot, prior to plunging, it will, if heated in an open fire, twist and bend all ways; the best way to avoid this is to get a piece of old gas-pipe, as near the size as convenient, and lay the spring in it, and then make the pipe hot. The spring will soon get sufficiently hot, and a regular heat will be the result, and it will be more likely to remain straight. The next thing will be to plunge it, but not in water. There are various opinions as to the best liquid to be used for this purpose; some prefer oil and water mixed. Another mode is to have a vessel containing a body of water, with about 1 in. of oil on the surface, so that the heated spring passes through the oil before it reaches the water. I give preference to a simple body of oil, and for a long thing like we have under consideration, a cylinder biscuit-tin will be found as good as anything to hold it. The spring being now hardened by the immersion in the oil, it must of course be tempered, and the best way to effect this is to blaze it—that is, after it has been placed in the oil, it should be taken out and held over the fire until the oil upon it catches light, and according to the degree of temper the spring is required to have, so long must the oil be allowed to flare. If a mild action is only wanted, it may be allowed to burn out, and be immediately dipped into water; experience alone can make any one proficient. The process of hardening a plain mandril is a piece of work with which great care should be again taken. Many people are under the impression that the mandril of a first-rate lathe should be all steel. This is an error, and it is only from want of knowledge that any one is impressed with this idea. To make a thoroughly good lathe the mandril must be composed of iron and steel. I am speaking now of a plain lathe; traversing mandrils are made of steel, but this is special. Taking, then, the plain mandril, the very best fagoted iron must be used, and round the part which is to form the bearing a thick ring of shear-steel must be welded. Cast steel will be of no use for this purpose, as it cannot be welded. The nose which eventually is to receive the chucks must be of iron. The mandril being fitted into its place as it must be, it will be ready for hardening, and the first thing to do will be to protect the nose from getting hot. To effect this, it must be covered with clay, bound on with thin binding-wire. It was at one time considered necessary for the heating of a mandril to have a hollow fire, but this idea has gradually died out. A mandril is a thing especially liable to break when heated and dipped into water; before dipping or plunging the mandril into the water, make a piece of iron hot, and stir the body of water with it. This is, to a certain extent, a safeguard; but nothing will make certain of its not breaking. The mandril must not be simply put into the water and taken out again, but moved about and allowed to remain until cold, or nearly so. The traversing mandril is made of the very finest steel to be obtained, and as it has to be bored through, and is not of sufficient substance to admit of welding, the nose is in the solid with it. In hardening one of this description, a somewhat different process will have to be gone through. An experienced turner will detect at once, when turning a mandril, whether it is likely to require to be made to a greater or lesser heat; for instance, if the steel turns short and crumbly, so to speak, it will require less heat than if it will admit of a long shaving being taken, and is, in fact, of a much softer texture. A traversing mandril will be about 14 in. long, and will only require to be hardened where the fittings or bearings take place; that is, about 2 in. from the collar at the front, and 3½ in. at the small end, leaving 1 in. quite soft at the extreme end, where the guides are to be fitted. The first thing to do will be to protect the nose from being made hard; this can be done, as in the case of the plain mandril, with clay. There are differences of opinion as to whether the nose should have the screw cut upon it before or after it is hardened. One thing is sure: that if cut first, it will certainly require correcting afterwards; but if it can be kept perfectly soft, it is better to do it when the mandril is hardened. One reason why more care is required with this kind than with a plain mandril is that it is longer, and there are two bearings to harden instead of one, and the nose being of the same steel as the mandril itself, it has more risk of becoming hard. Having protected the nose, proceed with all care to harden. First make a clean fire, free from clinkers, and heat the end that has the collar on it first; when sufficiently hot, which will be a deep blood colour, plunge it into cold water. To keep it as straight as possible, the best plan is the following: Before dipping, have a pail of clean water ready, and when the work is hot, take a stick and twist it round about in the pail, and so form a kind of diminutive whirlpool, the mandril being placed in the centre. The action of the water, in its circuitous course, tends to assist in keeping it in its original form; but take what steps you may, it is impossible to rely on its being straight after it has been through such a course of treatment. The one end having turned out well—that is to say, hard—and not very much distorted, the other part may be done in precisely the same way, and when this is finished, it will be consoling to find the mandril is still intact, as it has often happened that, before going so far, it has broken. But here even the anxiety does not cease: it may be perfectly hard, not scaled nor broken, but, when placed between the centres of the lathe, it may be so crooked that it would be out of all character to try and grind it into straight line again. Mandrils of this kind were at one time always tempered so that they could be turned with a diamond point; but since the introduction of emery-wheels, this is avoided, and they are left perfectly hard, and ground true by means of a small emery-wheel running between two centres driven at great speed. But before grinding it true—that is, absolutely so—it must be brought as near as possibly so by other means; and it is here that the anxiety comes in. It may possibly be found when the spindle is placed between the centres, that it is bent in two directions; should this be the case, it is not at all an easy matter to correct it. It must, however, be done with the pane of a hammer, and the mandril itself placed upon a flat surface, and the blow from the hammer take effect upon the opposite side to where the error is; this is where the danger of breaking is, because a sudden or uneven jar is likely to make the mandril suddenly two pieces. Sometimes the steel, from various causes, will bear the blow upon the same side. The mandril must be held firmly in the left hand, and with the right hand the hammer is applied gently. Do not blow the fire fiercely, but let the material get gradually hot through, and then, when it is so, do not plunge it in the water, and withdraw directly to see if it is cold; let it remain there till it is so. I have frequently heard a piece of steel crack some little time after it has been out of the water, but at the same time this may be no fault of the person who is hardening it—it is a thing that will, and unfortunately does, occur. Some authors direct that the nose of a mandril should be left as hard as possible This is quite an error: let the nose of all such work be kept as soft as possible. In the hardening of small centre screws, and for such things as horizontal cutters and the like, many are broken from the fact of being made hard on the screw part; it will be clear that if the screw fits at all tight upon entering, it leaves the chance of the point being twisted off. To avoid this, do not harden it, and the way to prevent it is to have only sufficient water in a flat-bottomed saucer, and when hot place the screw point downwards into it and move it about. Before the small body of water gets hot, remove it quickly into a greater body, and cool it. (J. H. Evans, 'Eng. Mech.')

Softening Iron and Steel.—*Softening Cast-Iron.*—(*a*) Heat the metal to a bright red, cool quickly in water, reheat, and then anneal by cooling slowly in ashes.

(*b*) Heat the metal to a red heat, let it lie a few minutes until nearly black, and then throw it into soapsuds.

(*c*) Place the castings, surrounded by saw-dust, in an iron box, close it up with clay to exclude the air, and subject it to a red heat for several hours. The castings must be cold before they are withdrawn.

(*d*) Hard iron castings may be softened by the following process, according to the *Deutsche Schlosser Zeitung*: The entire casting is brought to a red heat and then slowly cooled while covered with carbon dust. If the castings to be softened are small, a number of them are packed into a crucible and materials are added which at red heat give off carbon to the iron. The crucible is carefully closed, and is gradually heated and kept for a couple of hours in a furnace or an open fire, and then also slowly cooled. Suitable materials for supplying the carbon are cast-iron lathe-chips, soda, or raw sugar. If sugar is used, it should be added in considerable quantity.

Softening Files.—(*a*) Cover them with oil and hold them over the fire until the oil blazes; as soon as the flame runs all over the file, plunge it into water.

(*b*) Put them in a moderately hot oven for half an hour if large files; but if small the first plan is the best.

Haedicke observes that it is well known that in order to harden steel it is not necessary first to harden the metal and then to reduce its degree of hardness by tempering, but that any desired degree of hardness can be produced by hardening in various solutions. The temperature of this solution and its degree of conductivity for heat are important factors in the matter. The use of the press, too, in tempering, especially in the manufacture of saws, is of frequent occurrence. The saws are hardened in fat, and whilst still warm, or after placing between warm plates, tempered under pressure.

On a combination of these two processes depends the so-called direct press hardening. The apparatus used consists of a press provided with two hollow metal pieces, which, according to requirements, may either be kept cold by water run into them, or may be heated by steam or oil. The temperature can be read off on thermometers. The steel sheet to be hardened is transferred direct from the furnace to the press, and placed there between these two hollow slabs, subsequently leaving the press with any desired degree of hardness, and in perfect shape, not requiring any subsequent straightening. In the case of certain steels, the natural temperature of the press is often adequate to ensure the required condition of hardness. Only when the hollow plates are warmed by a large mass of metal being treated is it necessary to pass water through them. It is sometimes desired to have the pieces of metal that are to be hardened somewhat softer in the centre. This is readily possible by slight alterations in the shape of the hollow pressure plates when this process is employed.

Lead Tempering.—In some experiments made by the Chatillion-Commentry Steel Company with steel for gun tubes, projectiles and armour plates, the steel was heated to a red heat and allowed to cool gradually in a bath of melted lead. The elastic limit, breaking strength, and elongation were very largely increased. Brayshaw's salt-bath steel hardening furnace consists of a furnace which can be heated either by coal or producer gas, and a uniform temperature can be secured. The bath itself is a mixture of potassium and sodium chlorides fluid at 700° C. On immersing a cold tool in this mixture a partial solidification of the bath occurs, with the result that a gradual absorption of the heat is secured.

Feodorossieff's process for hardening steel and iron consists in the employment of glycerine. The specific gravity of the solution of glycerine may be varied between 1·08 and 1·26 at 15° C. by adding water as required. Its temperature may also be varied between 15° C. and 200° C. according to the hardness of the metal, it being found advisable to employ a high temperature for hard steels. To increase the quenching power of the bath, various salts may be added to the glycerine solution, manganese or potassium sulphate being added when a hard temper is required, and manganese chloride or potassium chloride for a softer temper. Owing to the wide limit of variation of the temperature of the solution and the quenching power, it is possible to treat very different qualities of steel by this method.

Copper.—*Hardening and Toughening.*—Everitt of Birmingham uses 1 to 6 per cent. manganese oxide (the best is the natural black oxide) and mixes this with the copper in a crucible. As soon as the mass is melted, the oxide is thoroughly stirred in, and the resulting scum carefully removed; it is then fit to cast. In the preparation of brass the same takes place, and then the zinc is added. Although chiefly used for brass plating, it is well adapted for other platings in which copper forms a chief ingredient. The copper is rendered more homogeneous, harder and tougher; it can be rolled at a red heat, thus saving a great deal of time and labour. It has shown itself best suited for steam-pipes, axle-boxes, ship-plates, etc. ('Iron Age.')

Trials made at the Mansfield Copper Works have proved that an addition of 0·45 per cent. of manganese-copper is sufficient to toughen copper, which only retains 0·005 to 0·022 per cent., while the greater portion, after having taken away the absorbed oxygen, is carried off in the refinery slag. Manganese-copper has also a beneficial influence upon the toughness and density of thin copper castings, such as thin sheets, tubes, kettles, cauldrons, and other kitchen utensils, which formerly were beaten or pressed into shape; copper cast with an addition of the alloy shows itself extremely tenacious, and tubes of 1¼ in. diameter and only 0·07 in. thickness will stand a pressure of over 1100 lb. per sq. in., when water begins to be pressed through the pores of the metal. It appears that "cast copper," which can be brought in any required shape without the necessity of soldering, beating, hammering, pressing or drawing, will in future play a considerable part in the arts and manufactures.

* * *

TILE-LAYING.

Tile-Laying for Hearths.—Whenever it is proposed to lay a tiled hearth in front of a grate, it is usual to have the tiles come level with the wood floor. The unusual exception to this is when a stone or cement hearth already exists and it is intended to fix a new grate, and a permanent stone or majolica fender kerb. In such a case, the hearth tiles are sometimes laid on top of the old stone hearth, to save cutting it up, but only when the fender kerb is going to be fixed permanently and immovable is this arrangement permissible. When the tiles are laid level with the floor, the hearth space, cut out of the floor boards, is always provided with a wood "border," as is shown in Fig. 226, this generally being of oak about 2 in. wide and ⅜ in. to ½ in. thick, and rebated in the floor boards. The border comes along the front and at each side of the hearth space.

The reason for referring to this is that the border, if already fixed, controls the arrangement of the tiles; while if not already fixed, it is desirable to carefully measure up the tiles and have the joiner make the border to fit. It will be seen how troublesome it is to have the tiles an inch larger or smaller than the space within the border. Quite apart from the work of cutting and fitting, there remains the fact that cut tiles never look so well as whole ones. Neither is it safe to say that a space 4 ft. wide will take 16 3-in. tiles correctly. Different makes of hearth-tiles vary a little in size, and even one maker's tiles may be found to differ if the hearth is made up of two colours. A difference as great as ⅛ in. may be found in 3-in. tiles, but so little as 1/32 in. will make ½ in. in a hearth 4 ft. wide. Nothing looks worse than having to fill in ½ in. or a wider space at each end of a hearth of tiles, or, as some do, make thick joints between the tiles. On the other hand, tiles may run over their nominal width, thereby necessitating cutting. Whenever it is possible the tiles should fit as accurately and be arranged as uniformly as the sketch, Fig. 226, shows, and in the majority of cases this is quite possible if care is used. On no account should a workman commence laying the tiles from one end of the hearth, resolving to make a fit at the other end *somehow*. Measurements should always be first taken, the tiles being correctly laid out on the floor. It is so often possible to get a nice fit by using "slips" (narrow tiles), which is far better than cutting, or, on the other hand, making up with cement. Workmen who, on measuring up, have found that an extra inch is needed in the tiles and have got this by making thick cement joints between the tiles, cannot be too greatly condemned. The appearance of thick cement joints is particularly objectionable.

It is always possible to get a correct relationship between the wood border and the tiles when the work is in a newly built room, or rooms, in which the carpenter can work to the tile-layer's measurements; but in houses already built the wooden borders already surrounding the existing hearths must be worked to. In such cases, if the tiles leave more than an ¼-in. gap each end, the space should be filled in with a wood strip, unless the margin is wide enough for a narrow "slip" tile of the same colour. Should the tiles be a little too wide, then the outside tiles at each end must be cut.

In cutting hearth-tiles the chisel is the recognised tool, and this may be the best thing to use when only a narrow strip has to be removed. In using a chisel, cut through the glazed surface of the tile first, then cut the unglazed back. If more than a ¼-in. piece has to be taken off the tile, or if a tile has to be cut to an awkward shape, then the plan that ensures the least breakages is to nip pieces off with a pair of 7-in. or 8-in. carpenter's pincers. About ¼-in. pieces may be nipped off at the time. No more time is occupied this way than when using a chisel, and a straight line can be worked-to quite as well. Tiles, after being reduced by either chisel or pincers, can have their edges rubbed true and smooth on a piece of stone with some sharp sand and water.

There is a difference of opinion as to whether a hearth should be laid before or after the grate is fixed. If the grate is already fixed, the hearth is laid to the grate, but when hearth and grate are new together, the writer favours the laying of the hearth first. The chief reason for this is that the grate is given a firm and level bed to

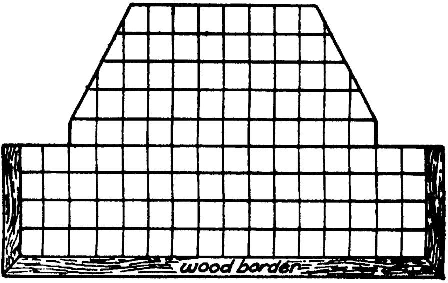


FIG. 226.

stand upon, and, most importantly, there is no cutting of tiles to fit the irregularities of the grate along its front where any rough work must be the most conspicuous. If the grate is fixed first it is usually packed up on some pieces of wood or slate in the front to admit of tiles being slipped under as well as possible, but it is a most unhandy job, particularly remembering that the laying of the tiles proceeds from the front towards the back. Then as the tiles are laid the packing has to be removed, with the possibility of the grate dropping a little. With this plan, too, there is not such a certainty of getting the ash-pan or economiser to fit as perfectly as it should do. Should the hearth be laid first, it will afford a firm and level base for the grate, and all that is necessary for the protection of the hearth during the grate-fixing is first a cloth, then some boards laid over.

Assuming that there is a suitable concrete bed or base, the first operation is to float on the cement on which the tiles are to come. This bed must be quite level and of even surface, or the laying of the tiles will be more or less like bad work. The cement is gauged 1 of cement and 1 of sand, and when first roughly laid on, it should not be too wet, but just moist enough to be spread out fairly level with a trowel. The "rule" is then used, this being a piece of wood like Fig. 227, cut away on the underside at the ends to a little greater depth than the thickness of the tile. The length of this rule is such that the notched ends rest on the wooden border of the hearth at each side. Some tile-layers use neat cement for the bed, in which case, if the cement is quick setting, it is customary to "kill" it, this being done by disturbing its initial set before it is hard, and remixing it with water. This makes it set more slowly and gives better time for the correct execution of the work.

FIG. 227.

Some little time before the tiles are wanted for laying they should be put to soak in water, for if any attempt is made to do without this, the work will be a failure by the tiles becoming loose. In laying them on the prepared cement bed, while it is moist, it is only necessary to have a little fluid cement on their undersides. Mix up some neat cement, on a board, to a cream, then as each tile is taken from the water rub its underside in the fluid cement, then place it in position on the cement bed. No cement is needed on the edges or sides of the tiles; they should come quite close together. Let the centre front tiles be laid first, careful measurement being taken to ensure the first tiles coming centrally. As already stated, if any cutting is to be done, let it be the end tiles, not centre ones.

As soon as the tiles are in position on the cement bed, a flat block of wood, with its extreme edges slightly rounded, is used for levelling and beating them down. This piece of wood is laid on the tiles and beaten lightly, being moved a little at almost every blow so as to ensure each tile being beaten evenly. A straight-edge can be used to test this. One effect of the beating will be to bring any superfluous water to the surface, and this can be wiped off, and if any joints look hollow, a little dry cement can be dusted on, and worked in, this being taken up by any moisture there may be in the joints.

The final thing to do is to clean off the surface of the tiles, and clean out the joints. This latter detail needs attention, as the top edges of the tiles are slightly bevelled and any cement settling there makes what appears to be quite a thick joint. Before the setting is quite hard, the hearth must be looked over for cracked, defective or small tiles. These can be lifted out with a thin knife blade, and replaced with others.

There is now a considerable demand for glazed earthenware fender-kerbs (majolica kerbs, as they are called) and as many of these have to be cemented in position, they require consideration. One important point is that no wood border is possible to use a "rule" on. There are kerbs of this kind that are sent out made up in one piece, and are placed down and used like a metal kerb, in which case the hearth is laid as already explained. If, however, the kerb is in several pieces, and is cemented in place, then the first thing to note is that it cannot be fixed on the wood floor, as its fixing could not remain sound long under these conditions. If the building is an old one and a cement hearth and its wooden border already exist, the question arises how the kerb can be fixed without placing it on woodwork, to which it will not adhere. It cannot be placed inside the existing wood border, as this would probably make the hearth too small, and if the wood border is taken up and the space enlarged, the trimmer and other joists are exposed. In consequence of this it may be considered that the kerb in one piece, just referred to, should be used, unless either the old hearth is large enough (as it sometimes is) to take the kerb within its area, or the bed of the existing hearth can be enlarged.

Assuming there is a proper foundation for the kerb, its fixing is done before the hearth is laid. It should be squared from the mantel jambs, and be bedded in compo. The joints can be made in plaster, and should a white joint be objectionable, a little colouring matter can be mixed with the jointing material.

In laying the hearth it is necessary to first lay two pieces of wood, or screeds, on the lower bed, these screeds being levelled to the required height and level of the cement tile bed. The cement is then laid and levelled by a straight-edge or rule running on the two screeds, as Fig. 228 shows. When this is done, the screeds can be lifted out, and their spaces filled in with cement. The tiles are then laid as already explained.

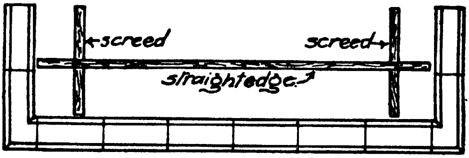


FIG. 228.

Laying Tiles on Perpendicular Surfaces around Grates.—For tiling the surfaces around the openings in which basket grates are fixed, or on the splays each side of grate "interiors," a different process is employed. In this work, the groundwork is either plain brickwork (which should be plumb and true) or brickwork roughly cemented over, the surface being purposely roughened to form a key for the cement bed of the tiles. The cement tile-bed, instead of being spread evenly over the foundation to receive the tiles, as with hearthwork, is plastered on the back of each tile before it is put up in position. The groundwork is well moistened before the tiles are put on it. Judgment is required in gauging the amount of cement material to put on the back of each tile. If too much is put on, part of it will be forced under the tiles already laid, and this will lift them out of truth. Any attempt to tap these back will cause others to lift and loosen. The cement generally used is Parian or killed Portland. The tiles must be well soaked previous to use, in fact they are usually taken direct from tub or bucket by the tiler as required. The groundwork must be kept nicely moist as the work proceeds, and if the mate brings the tiles, he should only serve a few at the time, or they will become too dry.

The customary way of going to work is to take a tile in the left hand and with the trowel spread some cement over the back surface, leaving a cavity in the centre and bevelling off all the cement clear from the edge of the tile. Before placing the tile up all the edges must be quite clean, as the tiles should come close together with no cement between them. The tile is then put up and pressed on to the brickwork with the hand. It is next tapped lightly, a few times, with the handle of the trowel, and this should give the tile a firm hold. As described with hearths, careful measurements should first be taken, that unnecessary cutting, or cut edges, or thick joints in conspicuous places, may be avoided.

In tiling up the splay sides of grates it is advisable to run the trowel down between the tiles and the iron-work of the grate (while the work is soft), or to get a crevice there by some means, otherwise the expansion of the iron-work, when heated, may loosen or even push some of the tiles off. It is one of the difficulties of tiling around grates to make allowance for iron-work expanding and contracting. It is on this account that slabbed panels are so much used. These are next described.

Slabbing Tile Panels.—What is known as slabbing tiles to form panels, is work that should now be practised in all ironmongers' and stove merchants' workshops. A large number, almost the majority, of grates used in good houses are now of a design called "interiors"—a design that will probably be common for many years—these consisting of the fire-box portion of a grate, leaving the side splays to be made up with tile-work. Sometimes the tiles are cemented up at the time of fixing the grate, but there exists a large demand for panels formed of tiles on a cement back—slabbed panels as they are called—as being easier to fix, and answering the purpose best. In show-rooms devoted to fire-grates, there is always a number of such panels exhibited, it being recognised that whoever buys an "interior" grate, must require tiles for the side splays.

Hitherto the making of slabbed panels has been done almost wholly by the tile makers, this practice necessarily increasing the cost very greatly. There is the tile-makers' profit, carriage to the tradesman's warehouse, packing, breakage in transit, and the handling of packages. Practically all this is saved when the panels are made by the tradesman—perhaps more, for it is a stock job that is given to workmen in slack times.

In this work it is best to use small tiles. The 6 in. by 6 in. tile is not favoured unless it is used as a centre tile of special design. The 3 in. by 3 in. tile and the 6 in. by 1 in. (and smaller) slip are the best, and it is now the rule to use tiles specially made for the work, these having keyed backs. It is not impossible to use plain backed tiles, but those with keyed backs are to be preferred, especially if the goods are to travel, or be subject to vibration.

The slabbing of tile panels has been considered a secret art and certainly the method of doing the work is not common knowledge. The chief secret detail lies in the cement used. Ordinary cements, Portland, etc., are not suitable, but most large builders' merchants keep a suitable cement. The writer uses what is called granite plaster, a quality known as brick-X (with sand), a specialty of J. Knowles and Co. (a firm having about twenty depots in London). This material, with sand, costs 3*s*. per 160 lb.

The way to go to work is to first fit up a firm bench or table, large enough to take a pair of panels or as much larger as may be desired. Cover the top of this with a slab of slate, fixed level. A piece of billiard table slate will do, or any firm of slate-workers will cut a slab to the required size. The panels are formed in a framework of wood. If certain fixed sizes of panels will be wanted, then suitable wooden frames can be made; but for irregular sized work, the edge of the bench must be made, so that slips of wood (battens) can be secured to it to form the frames for any size of panel proposed. Having seen the table top is clean, and arranged the frames to the size of the intended panels, the next thing is to arrange the tiles face downwards inside the frames. Needless to say, the tiles are well soaked in water first, as is necessary whenever tiles are to have cement adhere to them. The tiles should be taken straight out of the water and laid on the slate, and the cement should follow before the tiles become at all dry. Great care must be used in arranging the tiles, if a pattern is being worked to, as once the tiles are laid down they will not be seen again until the slab is set and hard and beyond alteration. In laying the tiles, let them come close together, as no cement need come between the edges; in fact a cement joint visible from the front (when the panel is finished) is not evidence of best work. The tile-makers cause a deal of trouble in this respect, for a 3-in. tile may be anything from $2\frac{7}{8}$ in. to $3\frac{1}{8}$ in.; even the same maker, supplying a second lot of the same colour, may not send tiles that will quite match in size (nor in tint). Needless to say, all joint lines must be true, as nothing catches the eye quicker when the panel is fixed and inspected. It would be thought from this that a table with a thick glass top would be desirable, the face of the panel thus being visible for inspection as the work progressed. In practice, however, the man who does the work soon gets over these possible difficulties.

Having arranged the tiles, face downwards, in the frame, and seen that the backs are moist, a little thin cement is laid in, this being worked into all crevices and the keyed spaces. Following this layer, while moist, comes a more substantial backing of the cement, making the slab to about half its finished thickness. On to this layer two irons are laid and pressed slightly in, after which the final amount of cement is added. The irons (which should be prepared ready) are strips of hooping, about $\frac{5}{8}$ in. wide by $\frac{3}{16}$ in. thick, nearly as long as the panel, and bent slightly circular. They are not circular on edge, but circular as they lie flat, forming a long)(. These form a bond, and are very helpful in stiffening the whole. The slabs should not be removed from the frames in less than two days, after which they should stand in a moderately warm place for another day or two to harden. When hard the faces are cleaned, and all cement (if any) carefully scraped out from the fronts of the joints between the tiles. No cement jointing material should be visible. Occasionally ordinary plaster is added to the special cement to hasten the setting, but this should not be done unless the maker of the cement says it is admissible.

Tiling Floors.—(*a*) To ensure a sound job, first prepare a foundation of concrete at least 4 in. thick; this must have three days to set before the tiles are laid, and must not be otherwise disturbed. Portland cement and sand should be used to lay the tiles. Cover the tiles with boards as soon as laid, and walk over them as little as possible for three days.

(*b*) The groundwork must be made quite level by means of screeds, with Portland cement and sand, three and one, upon a bed of concrete. No vibration must be in any way permitted. Where the tiles are to lie, have a pail of water and soak a number of tiles in this water for about a quarter of an hour. The Portland cement and sand bed must be quite set before commencing to lay the tiles. Have a person to serve you, and have a good mat under your knees. The man serving must make up some Portland cement, almost a liquid. Lay this evenly across the hall about the thickness of a penny coin, about 12 in. or 18 in. in the width, and begin laying the tiles. When the 18 in. of work is done, pat the tiles gently down with a plasterer's float, so as to get them all evenly laid, and, before proceeding to lay another 18 in., make a thin grout of Portland cement and pour it on to the laid tiles, so that it will run into all the joints, and when nearly set clean off with a clean rag. Now proceed further along the hall in the same way until finished. Have proper straight-edges to work with, and do not lean upon the tiles without a board under your hand. If it is a pattern with a border you desire to lay, have an assistant who is accustomed to this work.

(*c*) Let the tiles soak in a tub or pail of water until thoroughly saturated; screed the bed for laying them, one part Portland cement to three of good clean-washed fine road-grit, or even pit sand. Lay the tiles, after draining off superfluous water on the bed, which should not be very soft. Lightly beat them level with a flat piece of wood and hammer. Now with a piece of flannel draw off by lightly licking over the beaten surface all water, cement, and grit that works through the joints. This is essential to a clean job. Leave until hard—say, following day—when grout up all joints with "neat" cement, and when nearly set, scrape off and polish up with sawdust.

(*d*) For floor tiles use killed cement, which is Portland cement mixed up and allowed to set, care being taken not to let it set too hard. Then knock it up again so as to kill it. This will make it fat. Mix up sand and some fresh cement, and add some fat stuff to it, so as to make it work tough, and smooth well; soak tiles well, and let drain off. There should not be more than ¼ in. bed under tiles.

Fixing Tiles on Wood.—Attempts have been made to do this, using a cement of white-lead, or putty reduced to a sticky paste with linseed-oil, but this is not so successful as screwing the tiles on. The latter takes a little longer to do, but it is more lasting work and in event of injury it is so easy to remove a broken tile and replace it with a sound one. When large quantities of tiles are required, makers will prepare them with the extreme corners bevelled off, without extra charge, but failing this the corners can be nipped off with carpenter's pincers. This is a better, quicker and safer way of removing the corners than using a chisel. The object in removing the corners is to make a place for the screw to pass through to the wood.

Having prepared the tiles, they are put up one by one, the screw having a washer come beneath its head as Fig. 229. It is possible to get polished brass, or nickel-plated iron, screws and washers for this work, the washers being pan or saucer-shaped, as Fig. 230 shows. A wooden rebated bead should come at the outside edges, or at angles, of the tile work.

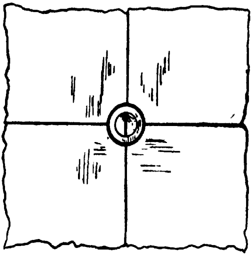


FIG. 229.

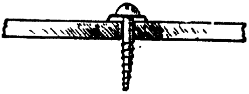


FIG. 230.

Mosaic Floor-Laying.—It may be stated at the outset that the designing of mosaic patterns is artistic work of a high order. The actual designers are, in fact, artists in every sense, and are employed as such. Their work is wholly done on paper, the laying of the pieces of marble or prepared tesseræ being work they have no knowledge of, except that which is necessary to guide them in the preparation of designs. On this account it is the exception rather than the rule to see the design formed by the workman in the execution of his work, for if we take a quite ordinary good border design, as Fig. 231, it will be seen that for a workman to lay this direct on a cement bed, each little piece one by one, and yet keep the design uniformly repeated, is a task that would be beyond many, and the cost would be excessive. It is sometimes done by means of templates in filling small areas, but for extensive work the plan of first arranging the tesseræ on gummed sheets of paper proves the most expeditious. Even with this, however, considerable practice is needed for good work. Any firm doing tile laying on a large scale will acknowledge that their men who are clever at laying ordinary tiles are not necessarily good at mosaic, in fact it appears to be more a rule that a good tile-layer is an indifferent mosaic hand and vice versa.

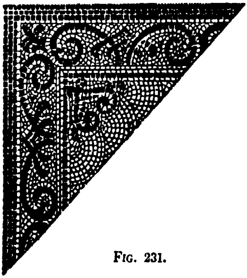


FIG. 231.

There are two recognised kinds of mosaic work for floors, one being that which is composed of small cubes of marble, the other having the marble replaced by burnt clay or tile ware. The latter, termed "Ceramic mosaic," is composed of small cubes of the same material as floor tiles, and as a rule the cubes are smaller than those made of marble.

Marble mosaic may be made up of many coloured marbles, from reds through various rich shades of brown, orange, yellow, greens, blue-grey, black and white. The pieces, which are irregular cubes, average ½ in. to ⅝ in. square, some being a little smaller, while pieces as large as ¾ in. are used. Much depends on the area and quality of the work, but, be it noted, mixed sizes are not used on the one job. The pieces of marble are sawn or cut to size, the waste and debris of marble works and quarries being put to good use in this way.

The first thing to be done towards laying a mosaic floor is to well ram the earth, and if a quantity of broken brick rubbish can be rammed in it is best. On the top of this comes 4 in. of concrete, then a floated face of Portland cement and sand, carefully screeded level, as already explained under Hearth and Floor Tiling. The cement used, in which the tesseræ (the pieces of marble) are bedded, is usually more of the nature of a plasterer's putty or fine mortar. Take a suitable quantity of chalk lime, and slake it with water, and then leave it in the open air a few days. Sift this and mix with it a good proportion of finely crushed brick and moisten with water. Let the mixture be well beaten and worked, and a good mellowed mortar will result. If the cubes are to be placed into position, a piece at the time, by hand, some of the mortar is first spread down, and then the cubes are tapped into this with a light hammer. When all are in, the surface is beaten by a block of wood struck with a hammer, or the surface can be rolled with a fairly heavy roller. When the whole has set hard the next process is that of rubbing the surface smooth and polishing it.

Before describing the polishing, reference must be made to the method of laying the cubes in large numbers at the time by previously affixing them to sheets of paper. This is a plan that is specially desirable when a design has to be repeated a great number of times, and in all cases it economises labour. The first thing to be done—in the office—is to sketch out the design in full size, on paper, and, in the case of repeating designs, then have a sufficient number of exact copies (on paper) made. Having a tray ready at hand, with cubes of different coloured marbles in divisions, the man (it is work commonly done by girls at tile works) commences covering the design with suitable cubes, all being placed face downwards and gummed in position on the paper. The design on the paper is always drawn the opposite hand to what is to appear on the laid floor, as the arranging of the cubes on the paper necessitates their being put face downwards, the whole being reversed, i.e. turned over, when it is laid on the floor.

The person who arranges the cubes on the paper has to be provided with an iron block and a tool known as a scabbling hammer. This is a hammer with a short handle and a long head, which is bevelled to a long but blunt chisel-edge each end. This is used to cut or chip the cubes on the iron block, to suit irregularities in the design. The pieces of paper, before the cubes are put on it, are cut to about 3 ft. square or any less dimension, in fact the 3 ft. size is rather large for handling. The operator, with the paper design in front of him or her, puts a layer of gum on a small portion, arranges the cubes on this, then gums a further space, and so on until the sheet is covered.

These prepared sheets of cubes are sent to the workman on the job—the mosaic layer. He should have a sketch design of the whole floor, and each sheet of cubes should be numbered to correspond with a numbered space on the sketch of the floor. Having prepared the floor with its top layer of mortar already described, the sheets are laid on it, paper side upwards, and carefully beaten down and levelled. They are then allowed to set firmly, say two to four days, according to the weather, and then the paper is soaked and cleaned off. The polishing is the next process.

The polishing of mosaic takes place as soon as the cubes are set, as just stated, but it is work that is also done at later periods, when the floor has become dirty and worn. In the latter case plenty of hot soda water must be used to remove any grease there may be, and to, as far as possible, get the dirt out. The polishing is done by rubbing a heavy piece of York stone over the work, the stone being provided with a handle, as Fig. 232. The size of the stone is about 9 in. by 9 in. by 4½ in. thick, and it should be of rather coarse grit, with open grain, which will not clog rapidly. By means of the handle, which is connected to the stone by two rings, as shown, the stone is pushed to and fro over the mosaic surface, sand and water being freely applied all the time. As soon as the surface is smooth and bright, it is well washed to remove all dirt and sludge, after which the polishing is finished with pumice powder, the stone being wrapped in blanket material for this process. Any small corners or awk-

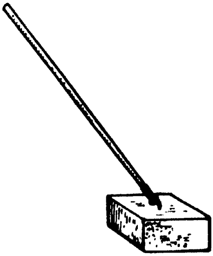


FIG. 232.

ward places must be polished with a smaller hand stone.

Another method of preparing the tesseræ cubes for laying is as follows: The design having been selected, a full-sized drawing is made and laid on a perfectly level surface. The tesseræ are then placed face downwards on this drawing, and, when the whole or a convenient portion has been completed, semi-liquid cement is poured over the back to a depth of 1½ in. to 2 in., and allowed to set and become thoroughly hard. The slab thus formed is then upturned and the face of the design shown. About 1 super. yard is the average size of these slabs, and they are fixed in the same way as tiles.

Mosaic Concrete Floors.—This is mosaic work in so far that it consists of small pieces of marble embedded in cement: but the work is done differently, and the result, although very good, does not resemble ordinary mosaic work. It is cheaper, and involves less labour; at the same time it admits of an ornamental design being made along the borders, or elsewhere. It is a good floor for landings and corridors, also for the halls and covered approaches of business places and institutions. The material is a concrete consisting of 2 parts of very small marble chips ($\frac{1}{16}$ in. to $\frac{1}{8}$ in. or ¼ in.) to 1 part of cement, this being laid as a fine cement concrete, and floated over that the flat sides of the chips lay evenly at top. The first thing to be done is to lay a rough foundation in ordinary concrete to within ½ in. of the finished surface, and screed rules are laid along both sides of the piece. The centre is the first part laid, and the surface is levelled from screed to screed with straight-edges and hand-floats. If the marble chips do not show up sufficiently, any defective or vacant parts may be filled up by hand. When the pavement has become quite hard, it is polished with a stone polisher and marble dust and water. The stone polisher is already illustrated, but it may be of smaller size and weight for this work, say 8 in. by 8 in. by 3½ in. thick.

When designs are to be introduced in mosaic concrete, wooden templates are used. It will be readily understood that if a piece, or pieces, of flat wood, of the thickness of the mosaic concrete, and of suitable design, be placed in position on the floor, the concrete being laid will come round them, so that when they are afterwards lifted, they leave a space of the required design to be filled in by concrete of another colour. It is possible to introduce quite intricate designs by this means without any difficulty, and by the expenditure of comparatively little extra time and expense.

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TINNING AND RETINNING.

(*See also*
ELECTRO-PLATING, COLOURING METALS, *etc.*)

To avoid a confusion that commonly occurs it may first be explained that, in this work, hydrochloric acid and muriatic acid are one and the same thing. Aquafortis is the commercial or cheap form of nitric acid. Chloride of zinc (also called killed spirits) is the hydrochloric acid or muriatic acid which has had zinc chips or cuttings dissolved in it until it will dissolve no more. Sal-ammoniac (chloride of ammonium) is a dull white crystalline substance like soda, and is used as a flux in tinning; it can be sprinkled on and melts when heated.

Copper.—If sheet copper is to be tinned, on one side only, let the side which is not to be tinned, and which will come next to the fire, be brushed over with salt and water and whiting. With a pad, which has been sprinkled with killed spirits, rub over the side that is to be tinned, also sprinkle it with a little powdered sal-ammoniac; now put the sheet over the fire, and when it is hot enough rub on it a piece of strip tin (pure tin) until a little of the tin melts. Take a pad of tow or wadding (cotton wool), sprinkle a little sal-ammoniac on it and rub the molten tin quickly over the entire surface that is to be tinned. Finally, with another pad of wadding which is saturated with oil, rub off all the superfluous molten tin and leave the whole smooth.

For tinning both sides of an article the foregoing process is not suitable, and a bath of molten tin must be provided. Make an iron bath of semi-circular section, and build this over a fire-box and melt the tin in the bath. Prepare the copper article with killed spirit and sal-ammoniac as described; dip or pass it through the molten tin (allowing the article to get as hot as the tin), then immediately it is withdrawn wipe the superfluous tin off all surfaces with a pad of oily wadding. The article should now be put into cold water, then taken out and polished with flannel and a thin paste of emery-flour and oil. Finally clean off with cloth.

Another method of getting a bright even surface is that adopted in making tin plate. The plate when it comes from the molten tin has the superfluous tin wiped (or rolled) off, then it is immersed in a bath of oil which is a little hotter than molten tin, which causes the tin to run again and spread very smoothly over the surface.

In tinning awkward-shaped articles, when they have to be tinned on one side only, some ingenuity is necessary. When it is required to tin the inside of a kettle spout, after the seam has been brazed, it is first necessary to remove the borax that has been used in brazing. This is done by pickling the spout in a weak solution of sulphuric acid until the borax is dissolved, then the spout is rinsed in cold water and dried. The inner surface is then prepared in the usual way—some killed spirit being first poured through, then a little powdered sal-ammoniac being shaken in. Have some tin melted in a ladle, and holding the spout by a pair of tongs, over a suitable vessel, pour the molten tin through it two or three times. Another method is to coat the outside of the spout with a mixture of whiting, salt and water, which, when dry, will allow of the spout being dipped in a bath of molten tin without any adhering to the outside.

In tinning an awkward-shaped article like a scroll or piece of hammered work, this must be dipped in molten tin and the surplus tin be drained out of it as well as possible, using a pad (dusted over with sal-ammoniac) wherever possible.

As a rule the first process in tinning is to chemically clean the surface. In the preceding description it is taken for granted that the surfaces are ready to receive the tin, but this is not always the case. Dilute sulphuric acid is used to remove impurities, after which the goods are well washed in plain water and well scoured to remove the blackness caused by the acid.

Copper Culinary Vessels.—Copper cooking vessels have to be retinned at regular periods and is a profitable branch of business, when a connection is obtained, as it is work that must be done regularly. It is not considered that any harmful results would be experienced from eating food cooked in plain copper vessels, but unless they were kept scrupulously clean, and vinegar very sparingly used, verdigris will appear, with serious effect. Grease is not the common cause of verdigris forming. Vinegar is the active cause of this poisonous compound appearing. Verdigris is in fact a compound of acetic acid (vinegar) and copper, formed by submitting copper to the fumes of vinegar, and known chemically as acetate of copper. By coating the copper with tin the action is prevented, and, so long as the tin surface remains intact, it is safe to prepare food in a copper vessel. It is the regular cleaning and frequent scouring of the vessel which, by wearing away the tin, makes retinning necessary.

It is of the greatest importance that the article to be re-tinned be perfectly free from grease or dirt—it must be chemically clean. To get it in this condition, first burn off all grease and dirt over the forge fire until the article is heated to a dull red colour, being particular where the handles are riveted on. Wipe out the inside with a small pad of tow, and set down to cool, and when cold, thoroughly scour with wet rough sand or powdered coke until it becomes clean and bright. If the dirt has eaten into the metal, or if the surface is very black, wash it with raw spirit of salts (hydrochloric acid), using a piece of tow tied to the end of a short stick. Rinse in cold water, and then scour bright. When quite bright, wash the article well with cold water, taking care that no grit or sand remains inside, and then dust the inside with powdered sal-ammoniac. The outside must be prepared by coating it with a mixture of salt and whiting, which should be of the consistency of cream; this prevents any tin adhering to the outside. Should the top of the outside require to be tinned to the depth of about 1 in., as is the case with all new stewpans, it should be thoroughly cleaned as before explained. A strip of tin or sheet iron 1 in. deep should be tightly held round the top of the stewpan, while the mixture of salt and whiting is rubbed over the stewpan below the band. Remove the band, and dust the bright surface of the stewpan, formerly covered with the tin band, with sal-ammoniac.

A rubber, by which the molten tin is worked over the copper surface, is made as follows. Take a piece of wire about ¼ in. thick and make a 2 in. coil on the end of it. Tin the coil by soaking it in raw spirit of salts for some time, and then dipping it in a saturated solution of sal-ammoniac and killed spirit, and rubbing whilst hot on block tin or tinman's solder. Hold the stewpan over a forge fire, and in it drop a small quantity of pure block tin; the amount of tin depends on the size of the vessel. The tin will soon melt, after which it must be rubbed over the copper with the rubber until the surface of the copper alloys with the tin. Any difficulty in getting this result may be overcome by repeatedly and alternately dusting with powdered sal-ammoniac and vigorously rubbing over the tin with the rubber. The outside top edge of the pan may be more easily tinned with a soldering iron, the solution of sal-ammoniac and chloride of zinc being used instead of the powdered sal-ammoniac. Some care should be taken that the article is not allowed to get too hot. The highest heat is when the molten tin can be rinsed round the inside of the article. The molten tin is then quickly emptied out into another pan, if more than one is to be tinned, and the pan quickly wiped out with a pad of clean tow, which will remove any superfluous tin, after which it must be suddenly plunged into a vessel of cold clean water, and then dried by rubbing with clean hot sawdust.

When about to pour molten tin from one pan into another, great care should be taken in seeing that the pan into which it is to be poured is perfectly dry and warm, otherwise the possibility of the tin flying will make the operation highly dangerous.

If a pan, spoon, or strainer requires to be tinned all over inside and out, it should be thoroughly cleaned, and the inside and outside should then be treated with saturated solution of sal-ammoniac and killed spirit of salts, and then dusted over with powdered sal-ammoniac. A vessel containing molten tin should now be in readiness, into which the article should be carefully plunged and washed. The article is then wiped with tow, plunged in cold clean water, dried with hot sawdust, and polished with whiting.

Old Copper Pans.—When all the repairing is complete, the bruises are taken out, and the bottoms of the stew-pans and saucepans are laid flat or made level, the preparation for retinning properly begins. Commence with the application of a coat of hydrochloric acid to eat off or remove the dirt and the portions of the old or previous tinning. When the vessels have stood a sufficient time, they are thoroughly scoured inside with good sharp sand, with the addition of some common salt, and then washed clean, care being taken that all the old tin is off when burnt, and that nothing greasy gets inside. Then while the vessel is yet damp a coat of finely powdered sal-ammoniac is sprinkled over the inside, and a coat of wet salt and whiting is put on the outside to guard against the effects of the different gases from the fire and to prevent any tin adhering.

Take a quantity of block or ingot tin and slowly melt it in a ladle, being careful not to allow any part of it to become too hot or get burnt. When the tin is melted and ready, then warm and dry the vessel to be tinned, and pour a sufficient quantity of tin into it. Next take a pad with powdered sal-ammoniac dusted on it, and with it rub the liquid tin over the entire inside surface of the vessel until every part is well covered, and then pour out the bulk of the liquid tin. After heating the vessel to a uniform heat all over, take a wisp of clean, soft tow, the hand first being protected by means of a glove which has had the tips of the fingers cut off as far as the first joint, and whisk it in a pan of powdered sal-ammoniac; then with a light hand and a few quick motions, first around the left side and then the right, and then across the bottom, wipe out the residue of the tin, leaving only a clear bright coat on the surface of the vessel. Only by practice can the best results be obtained. While the tinning process is going on, a boy is busily scouring and preparing other vessels. The tinning process being over, the next in order is to scour each article with clean white sand on the outside to remove the salt, and inside any sal-ammoniac that might be left. This scouring must be carefully done, and it is best to have a separate place for each operation, so that when the outside is cleaned off the inside can be scoured without fear of contamination from the salt; because if the outside scouring wisp should by mistake get on the inside the work would be spoiled. It is best to keep the wisps far enough apart to ensure them from being taken up and used by mistake. After the sal-ammoniac has been scoured off and the surface outside and inside is clean and bright, the articles are rinsed off in clear water and dried in clean, fine sawdust kept in a large box, and then stood around a large forge-fire to be dried more thoroughly. Next brush off the sawdust, and with a clean, soft linen or cotton rag and clean whiting, polish the inside; then with another rag and a little crocus polish the outside.

Small Articles.—Place them in warm water, with a little sulphuric acid added to it, which will clean them; then powder some sal-ammoniac and mix it in the water, stirring well until all is dissolved. After washing the articles in clean water, place them in the solution for a few minutes; then lay them by the fire to dry. Procure a pan resembling a frying-pan in shape, the bottom of which must be full of small holes. The pot for melting the tin must be large enough to admit this pan. Cover the bottom of the perforated pan with the articles that are to be tinned, and, after sprinkling a little powdered sal-ammoniac over the surface of the molten tin to clear it from dross, dip the pan containing the goods into it; after all smoke has disappeared, lift it out and shake well over the pot, sprinkling a little sal-ammoniac over the goods to prevent them from having too thick a coat, then cool quickly in cold water to keep them bright.

Brass or Copper.—(*a*) Plates or vessels of brass or copper, boiled with a solution of stannate of potash, mixed with turnings of tin, become, in the course of a few minutes, covered with a firmly-attached layer of pure tin.

(*b*) A similar effect is produced by boiling the articles with tin filings and caustic alkali, or cream of tartar. In the above way chemical vessels made of copper or brass may be easily and perfectly tinned.

(*c*) Boil 6 lb. cream of tartar, 4 gal. water, and 8 lb. grain tin or tin shavings. After the materials have boiled a sufficient time, the substance to be tinned is put therein, and the boiling is continued, when the tin is precipitated in its metallic form.

(*d*) The articles are first put in dilute sulphuric acid, and when quite clean, washed in warm water. They are then dipped in a solution of killed spirits, and afterwards plunged into a bath of molten tin, to which a little zinc has been added. When taken out the articles are rubbed with a pad, then plunged into hot water.

(*e*) Add to 10 quarts of water 3¼ oz. of cream of tartar and 14 dr. of protochloride of tin. Heat the whole to boiling, then immerse the articles to be tinned. This process is convenient for small goods such as pins, hooks, etc., which are put in a tin sieve to be immersed.

(*f*) Prepare a bath of distilled water, 66 gal.; cream tartar, 6½ lb.; tin protochloride, 10½ oz. The powdered cream of tartar is dissolved in 44 gal. warm water, and the tin salt in 22 gal. cold water. The two solutions when mixed become clear, and the resulting bath has an acid reaction.

Distilled water, 66 gal.; pyrophosphate of potash or soda, 13 lb.; protochloride of tin, crystallised, acid, 21 oz.; or the same fused, neutral, 14 oz. The whole is dissolved at the same time on a metal sieve, and, after stirring, the bath is clear.

Either of these solutions is kept in a barrel with the top off. This barrel has at its lower part two tubes placed one above the other, connected with a small boiler built below the level of the bottom of the tank. The tube, starting from the bottom of the tank, reaches nearly to the bottom of the boiler; the other tube, which is placed about 3 in. from the bottom of the tank, is connected to the top of the boiler, as Fig. 233. A bent safety tube, connected only to the boiler, prevents any explosion, should there be an ob-

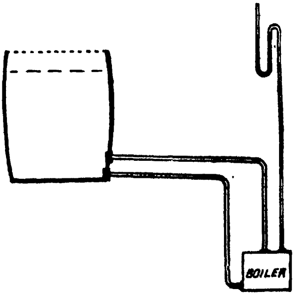


FIG. 233.

struction in the other tubes. A small quantity of water or mercury in the bent arm of the safety tube will prevent the escape of steam, when it does not exceed the working pressure required, or a safety valve may be used. When the boiler and tank are filled with liquid, as soon as heat is applied, the expanded and lighter liquid will rise through the upper pipe into the barrel, while the colder and denser one will flow into the boiler through the lower pipe. A continual circulation is thus obtained, which keeps up a constant agitation of the contents of the bath. Large articles are cleansed and rinsed, and piled in the bath with a few fragments or spirals of zinc; the surface of the zinc should be about $\frac{1}{30}$ of that of the tinned articles. For small objects, such as pins or hooks, dispose them in layers about 1 in. thick upon perforated plates of zinc, which allow of the circulation of the liquid, and have their edges turned up so as to prevent the objects from falling off. These plates should be removed from the bath in the inverse order in which they have been put in. These zinc plates must be scraped and cleaned, so as to present fresh surfaces of zinc instead of the white crust, which prevents its contact with the articles to be tinned. The time for this is 1 to 3 hours. Then remove all the objects, and add to the bath 9 oz. pyrophosphate of soda or potash, and as much fused tin protochloride. Whilst the solution is going on, scratch-brush the large articles, and stir the small ones about with an iron fork, to change the points of contact. The objects are then again steeped in the bath for at least 2 hours. The large pieces are scratch-brushed again, and the small ones rendered bright by mutual friction. Then dry the whole in dry and warm fir-wood saw-dust. Cast-iron cooking vessels thus tinned have a bright appearance, and have the advantage of never communicating any taste, smell, or colour to the food cooked in them, even when the tinning, after long use, has completely disappeared.

Colour of Tin Deposit.—If the tin deposit is grey and dull, although abundant, prepare the bath, once or twice, with the acid crystallised tin protochloride. With a very white deposit, but blistered and without adherence or thickness, replace the acid salt by the fused one. In the latter case, also diminish the proportion of tin salt, and increase that of pyrophosphate; a great deal of the success of the operation depends upon the quality of the pyrophosphate. When a tinning bath has been worked for a long time, decant the liquor to separate the zinc pyrophosphate formed. And when, after several years, the solution is entirely used up from the alteration of the salts, it should be kept in preserving tubs, where the objects to be tinned are put after cleansing.

The "Boiling White" Process.—By "boiling white," a thin coating of tin may be applied to small articles made of brass and copper. Domestic pins are sometimes so treated, thus acquiring their brightness. In circumstances when the colour of brass hinges or nails would not match the object for which they were intended, this method of tinning would render them fit for their purpose and save purchasing things made of a white metal. Similarly, small parts of artificial baits used for sea or fresh-water fishing can be easily tinned; this makes them shine in the water, and renders them more conspicuous to the fish. Tackle-makers and others may therefore make brass swivels and other oddments of tackle appear like silver and permanently bright; and other instances where boiling white would be useful may occur to the workman according to his special occupation. The method is extremely simple. A piece of block tin, weighing about ¼ lb., must be obtained. Melt this in an iron ladle, and whilst liquid pour the metal into a wide-mouthed vessel about half full of cold water. A bucket or tin pan would answer the purpose. In pouring the molten tin the ladle should be held at some height above the water, and it is desirable to stand on a chair. If not poured into water the tin would be spilt. The tin, immediately it touches the cold water, forms "grain" tin, spreading, and at once assuming a flaky consistency. Having drained off the water from the bucket or pan, a box (without a cover) must be made of perforated zinc to contain the tin. A piece of zinc 1 ft. square makes a box large enough for small articles, for which boiling white is specially convenient; but there is no reason why it should not be practised quite satisfactorily on a larger scale. Having marked out the size of the box, cut out the square piece at each corner with snips or strong scissors, and when the sides are turned up all round, which is easily done with a mallet or hammer over an iron stake, the edges will meet. To keep the four corners of the box together, small pieces of fine copper wire should be inserted through the holes in the zinc and twisted tightly with the fingers. Having made the box, which need only be a rough affair, put about half the grain tin into it. Then place upon this the brass nails, or whatever they may be, and on the top of them the remainder of the tin, so as to cover them. For ease of examination it is better, if possible, to string or attach the articles to a piece of copper wire, the two ends of which are left projecting from the top of the box. The brass should be chemically clean, as then it will take the tin more readily, and, if lacquered, the lacquer should be removed by boiling in caustic potash. Before tinning, the articles will be further improved by holding them in dipping acid for about a second, then immersing immediately in clean cold water. If this is not very rapidly performed the metal will turn black. When the things have been prepared and placed in the zinc box amongst the grain tin, the whole is boiled in a saucepan nearly full of water; a saucepan enamelled inside is to be preferred. Whilst the water is boiling, some cream of tartar should be liberally sprinkled on the top of the tin. The process of boiling will occupy nearly ½ hour, and if the water in the saucepan becomes insufficient more should be added. The boiling can be done over a fire, but a gas-burner is handier in a workshop. By examining the articles it is easy to ascertain when they have received sufficient coatings of tin, as then they will appear of a uniform dull grey colour. If not, the boiling must be continued for another five or ten minutes until the brass is no longer visible. Then take them out, rinse in clean water, and dry with a cloth. A rub up with washleather or Selvyt cloth will quickly render them brilliant, and they will look as if they had been nickel-plated. The grain tin should not be thrown away, as it can be used again and again. As this is a rather lengthy process, it is a good plan to boil a number of the articles at the same time. (Hasluck.)

Brass Wire.—(*a*) Have two baths, one containing the molten tin, kept at a proper temperature, the other a saturated solution of zinc chloride (killed spirit). Immerse the coil of brass wire in a boiling solution of caustic potash, and remove it to a bobbin, having a fixed spindle and one movable end. Pass the wire by means of suitable hard wood or brass deeply-grooved pulleys, so that it shall pass through the zinc chloride bath into the molten tin, and after immersion cause it to pass between the grooves of two pulleys, revolving in contact with each other, so that the grooves form a hole equal in size to the tinned wire; these will squeeze off any superfluous metal that may be carried up from the bath; carry forward the end and attach to it a fresh bobbin, and wind off at a suitable speed. The wire must be raised sufficiently in temperature before it will take the tin, and it must be properly cooled again before it reaches the final bobbin, which can be effected by placing it at a proper distance from the tin bath.

(*b*) Another method is to have a solution of tin perchloride which is prepared by passing washed chlorine gas into concentrated aqueous solution of tin salt, and expelling the excess of chlorine by gently warming it, then diluting it with 8 to 10 times its volume of water, and filtering it if necessary. The article, well pickled in dilute sulphuric acid, polished with sand and a steel scratch-brush, and rinsed with water, is loosely wound with a zinc wire, and immersed for 10 to 15 minutes, at the ordinary temperature, in the dilute solution of tin perchloride. After being tinned in this way, it is raised, brushed with a scratch-brush, dried and finally polished with whiting. Cast iron, wrought iron, steel, copper, brass, lead, and zinc can be tinned by this method.

Iron Wire.—(*a*) The first process is to immerse the wire in raw hydrochloric acid, and let it remain until all scale is dissolved off. The wire is then put into killed spirit for a time, and it is then ready to pass through the bath of molten tin.

(*b*) A more elaborate process as adopted in works where large quantities of wire are dealt with is as follows: As the wire comes from the annealer it goes to a cleaning room, a well ventilated place, as the acids used give off injurious fumes. Along the side of the room are the various pans or troughs of chemicals. The first will contain grounds, which is old sour ale or distillers' wash, and sulphuric acid. There would be 5 or 6 pints of sulphuric acid (vitriol) to 4 or 5 gal. of grounds. The wire is immersed in this for about ¼ hour to remove all scale or mechanical impurities. It is removed from this bath by means of iron hooks, then dropped into a bath of clean water. In this bath it is examined to see that all scale or dross is removed, as, if not, it must go back again. If it will pass it is put into still another bath of clean water to ensure all the acid being removed. The acid causes bubbles to rise, and when these cease the wire may be considered clean. From this room the wire goes to an adjoining room which is devoted to the tinning. Only sufficient is taken to be dealt with at once, as if exposed to the air for long it will require re-pickling. Here the wire is passed through a bath of muriate of tin, and, the wire being put on suitable reels, it next passes first through killed spirit then through the bath of molten tin. On leaving the tin bath the wire is drawn through hard blocks or close fitting grooved pulleys to remove any excess of tin. Over each bath in the cleaning room a stout projecting rod should be fixed in the wall so that the coils of wire may be suspended to drain over the bath that it is taken from.

(*c*) The following is Heeren's process for giving iron wire the appearance of silver. This is done by a thin film of tin. The iron wire is first placed in hydrochloric acid, in which is suspended a piece of zinc. It is afterwards placed in contact with a strip of zinc in a bath of 2 parts tartaric acid dissolved in 100 of water, to which is added 3 parts tin salt and 3 of soda. The wire should remain about 2 hours in this bath and then be removed, and made bright for polishing, or drawing through a polishing iron. By this galvanic method of tinning, wire which has been wound in a spiral, or iron of other shape, can be made quite white, which is an advantage over most other methods, where the wire is tinned in the fire and then drawn through a drawing plate.

Small Iron Articles.—(*a*) When small iron castings have to be tinned all over, they must be thoroughly cleaned, then immersed in dilute sulphuric acid to remove scale. Should black spots then show the pickling must be continued, and, if necessary, they may be scrubbed with a stiff brush (wire for preference) and a little fine sand until the iron has a clean grey surface. The articles are dipped in killed spirit, dusted over with powdered sal-ammoniac and are then ready for immersion in the bath of molten tin. If any parts appear to be uncoated after passing through the tin, sprinkle with sal-ammoniac, and put into the tin again. The articles must be kept in the tin until they are as hot as the tin, otherwise the coat will not be perfect. It is not desirable to have the tin too hot, but it must be hot enough to drain off the articles as they are lifted out of it. When articles are required to have a high polish, the tin should be allowed to drain off, and not be wiped off. They will then take a high polish if gone over with a rag dolly attached to a lathe, with a little polishing lime.

(*b*) Another method of tinning iron goods is as follows. Iron which is to be tinned must be previously steeped in acid materials, such as sour whey or distillers' wash; then scoured and dipped in molten tin, having been first rubbed over with a solution of sal-ammoniac. The surface of the tin is prevented from calcining by covering it with a layer of fat.

(*c*) The following process is not sufficient protection for iron, as the tin is a mere film, but it may be useful when thicker coats of tin are to be applied by other processes. For the bath, dissolve with the aid of heat, in an enamelled cast-iron kettle, ammonia-alum, 11 oz., and fused tin protochloride, ⅓ oz., in 4½ gal. soft water. The pieces of iron, previously cleansed and rinsed in cold water, are steeped in the solution as soon as it boils. They are immediately covered with a film of tin of a fine white dead lustre, which may be rendered bright by friction. The bath is maintained at the proper strength by small additions of fused tin protochloride. This bath is convenient for a preliminary tinning of zinc; when the ammonia-alum may be replaced by any other kind of alum, or by alumina sulphate; but for wrought and cast iron and steel this substitution cannot be made.

Case-hardened or Hard Steel Articles.—This may be done without affecting their hardness, if care is used. Tin melts at 442° F., while polished steel assumes a yellow tint at 470° F. The first process, as with other iron goods, is to remove scale (if any), either from foundry or forge, by means of a pickle of dilute sulphuric acid, and then scratch-brushed or scoured with sand. If the articles are of steel and have been quenched or hardened in oil, every trace of the oil must be removed by immersion in boiling solution of soda; next the surface must be made chemically clean; even the film of oxide, which causes the yellow colour, will prevent the proper adherence of the tin to the steel. Have a bath consisting of 1 part of hydrochloric acid to about 20 parts of water, hold the article with a pair of tongs and stir it for a few seconds in the bath, withdraw it, and, while still wet, instantly immerse it in the molten tin, the surface of which should be kept from oxidising by a top surface of clean tallow. The article, when withdrawn, will be found completely tinned. Precaution must be taken not to overheat the tin, but keep it down to the proper melting temperature or the hardness of the articles will be affected.

Iron Saucepans.—If the saucepan is an old one it must be put on the fire and allowed to get nearly red hot, which will get rid of all the grease; then make a pickle of the following proportions: Oil of vitriol, ½ lb.; muriatic acid, ¼ lb.; water, 1 gal. If the saucepan can be filled so much the better, if not keep the pickle flowing over it for say 5 minutes, pour out, rinse with water, and scour well with sand or coke dust with a wisp of tow; rinse well with water. If the pan is clean it will be of a uniform grey colour, but if there are any red or black spots it must be pickled and scoured again till thoroughly clean. Have ready zinc chloride, that is, hydrochloric acid in which some sheet zinc has been dissolved, some powdered sal-ammoniac, some tow, about 18 in. of iron rod ¼ to ⅜ in. thick, one end flattened out and bent up a little and filed clean, and some bar tin; dip a wisp of tow in the zinc chloride, then into the powdered sal-ammoniac, taking up a good quantity, and rub well all over the inside. This must be done directly after the scouring, for if allowed to stand it will oxidise; put on the fire till hot enough to melt the tin, the end of the bar of tin being rubbed over the heated part till melted; run down about half the bar, and with the flattened end of the iron rod rub the tin well over the surface, taking care not to heat too large a surface at once, nor to let it get too hot, which may be known by the tin getting discoloured, when some dry sal-ammoniac must be thrown in. Having gone all over it, wipe lightly with a wisp of tow, just made warm enough that the tin does not stick to it; when cold scour well with sand and tow, rinsing with plenty of water.

To make the best job of retinning it is important that all the old tin be removed by filing, scouring, or machining, and then, having given a new clean surface, proceed as with new goods. New ware has the surface prepared by one of these methods, after which the article is gradually heated to redness, and then allowed to cool. Assuming that there is no grease, another method of preparing the surface is to use a pickle of dilute sulphuric acid, used warm. After this the article is immersed in another pickle of dilute hydrochloric acid, where it is allowed to remain some time. Lastly, it is subjected to a pickle of killed spirits, and tinning is proceeded with as described. If any parts do not take the tin, the article must be re-heated to the melting point of tin, and a little grain tin rubbed over with some sal-ammoniac. The hot tinned surface is wiped out with a tow pad as usual.

Zinc.—The proportions of the bath are as follows: Distilled water, 66 gal.; soda pyrophosphate, 11 lb.; fused tin protochloride, 35 oz. A thin tinning is obtained by simple dipping, and one of any thickness by the aid of the battery.

Cold Tinning.—Block tin dissolved in muriatic acid with a little mercury forms a very good amalgam for cold tinning; or, 1 part of tin, 2 of zinc, 6 of mercury. Mix tin and mercury together until they form a soft paste. Clean the metal to be tinned, taking care to free it from greasiness; then rub it with a piece of cloth moistened with muriatic acid, and immediately apply a little of the amalgam to the surface, rubbing it in with the same rag. The amalgam will adhere to the surface and thoroughly tin it. Cast iron, wrought iron, steel, and copper may be tinned this way. Those who find it difficult to make soft solder adhere to iron with sal-ammoniac, will find no difficulty if they first tin the surfaces in this manner, and then proceed as with ordinary tin plate.

Tin Plate.—It is unnecessary to go into the question of rolling the sheets used for tin plate, and, therefore, the following description refers to the treatment of sheet metal ready annealed and cut to size. In days gone by the sheet metal was of iron, whereas now steel is mostly, if not always, used.

To get a clean metallic surface, such as is requisite to receive the tin, the iron must be dipped repeatedly into quite dilute sulphuric or hydrochloric acid, then polished and scoured, each one separately, with sharp sand over the entire surface. It is now ready to receive the tin, and passes to the tinning room.

In this room are a number of baths or pots, called kettles, all of the same height, placed in a row, and heated with fires beneath them. They are called the grease kettle, the tinning kettle, the brush kettle, the fine tin or roller kettle, and the grease kettle. The different operations performed in these kettles take place in this order: The pickled and scoured plates are put in the first kettle and thoroughly coated with grease, which should be pure tallow, but palm oil is largely used. Then it goes to the tin kettle, in which it is moved about until evenly tinned all over. From this it goes to the third kettle, also containing tin. Here each individual plate is taken out and brushed with an oakum brush or pad of hemp to remove the coarser particles. It is next put in the fine tin; then in the last kettle, which also contains hot grease, on a grating, or moved up and down in it by rollers. When the plates come from this kettle they are placed on racks to cool. The tinning is now completed, but they do not look very nice, owing to the adherent grease. To remove this they are drawn through three or four large boxes filled with slaked lime, sawdust, bran, or flour; flour is the best of all, for it cleans them better, and after it gets saturated with grease the flour can be used for cattle feed.

After the tin plates leave these boxes they go to the polishing bench to remove the dust. This bench consists of a table covered with woollen cloth, or a sheep pelt, and the sheets are rubbed singly with a rubber made of wool or sheep-skin, which brings out the pure, fine lustre of the tin.

The tin is next assorted by a careful inspection of both sides, and classified as first, second or third quality. Sheets that are imperfectly tinned are sent back to the tinning room, while the rest are packed in wooden boxes and the brand is burned on.

There is not the least doubt that instead of tallow or oil, killed spirit is now being largely used as a flux, but those capable of judging consider it a likely cause for the plates rusting at an early date.

In an up-to-date plant that was inspected, the last hot grease pot was fitted with rolls capable of such precise adjustment that any desired amount of tin could be squeezed off. This enabled any quality of work to be produced with the utmost accuracy and economy of tin.

Tin-Plates.—Before a recent meeting of the Institution of Mechanical Engineers Mr. R. B. Thomas read a very instructive paper on the manufacture of tin-plates. After giving a brief history of the industry he described the manufacture as follows: It commences with the rolling of the mild steel bars, which contain 0·1 per cent. of carbon. These are from 6 to 10 in. wide and from ⅜ to ⅞ in. thick. They are cut up into quite short lengths and are passed between cast-iron rollers, chilled to a depth of about ¾ in. These rollers are 19 in. diameter and usually 26 in. long. The rolling speed is low, not more than forty revolutions per minute. Four men are attached to each mill, one on either side of the rollers, and one at the furnace, while the fourth looks after the doubler's shears. The material is heated and rolled 5 times. After the first heating the long edge is presented to the nip of the roughing rollers so that the material is stretched in the direction of its width. Two pieces are passed through alternately, one being returned over the roll while the other goes through, until each has been passed through 4 or 5 times. After the second heating each slab is twice rolled, by which time it is reduced to about 14 B.G. It is then doubled upon itself and the double edge flattened down under a squeezer. Every once-doubled piece is re-heated, stretched in the finishing-rolls, and again doubled, so that it now consists of four layers at this stage. After a squeezer has flattened the double edge down, the edges which came together on first doubling are trimmed off in the shears, and the pieces returned to the finishing furnace. The fourth heating is followed by a repetition of the last operation. The twice-doubled piece is stretched and doubled so as to form eight thicknesses, the open ends being trimmed with the shears before the pieces are returned to the furnace for the final heating; they now consist each of eight layers and are finished off to length in the rolls and are piled on the side of the mills, away from the furnaces. The object of the doubling is to preserve the necessary thickness of plate upon which the rolls may bite. In some mills the process necessarily differs from the description given, which represents the common practice in South Wales. The next process is to shear the sheets to standard sizes, after which the plates are treated with warm dilute sulphuric acid for the removal of the black oxide scale formed on the surface during the rolling. After pickling, the plates are black annealed by "soaking" in a high temperature to soften the steel. This stage is preparatory to cold rolling, and has the effect of removing all traces of water stains. During cold rolling the plates, now cleaned and annealed, are subjected, under great pressure, to the action of chilled rolls. This has the effect of giving them a good surface. These rolls, 26 in. long by 19 in. diameter in the body, are in all respects like the mill-rolls, except that the chill is ½ in. deeper. The speed is about fifty revolutions per minute, and at each pair of rolls a boy sits on a stool with a pack of plates resting on his knees, and on a guide between the housings. He thus deals the plates one by one in rapid succession through the rolls, using his hand and thumb to separate or feed the plates singly. Behind, the plates are picked up by another boy and carried back to the next line of rolls, where they are put through in the same way and carried back to the last line of rolls. Each plate thus gets three passes, one in each line of rolls.

The cold rolling causes the soft annealed plates to become hard and rigid, and they require to be annealed again to enable them to recover from the imposed strains and to assume the pliability required in tin plates. This is "white" annealing, and the method is the same as in the "black," except that the heat used is not so great, and the time given is only about 7 hours. The plates are then finally pickled to clean the surfaces for the coating of tin. After white pickling the plates are not allowed to dry before they are put into the tin-pot, which consists of two parts. In the first of these the surface of the molten tin is divided into three compartments. The second is surmounted by the "grease-pot," filled with palm oil. Two men work the pot, one feeding the plates into the metal, and the other receiving them with a pair of tongs as they emerge from the grease-pot, and transferring them to the cleaning machine. A layer of liquid flux (chloride of zinc) floats on the surface of the metal in the first compartment. The plates are fed down through this and are pushed through the metal along guides by means of a hand-fork, until they are taken by the rolls. As the plates emerge from the first section of the pot they meet the outside guides, and are bent into the second pair of rolls, finding their way thus through the second section of the pot and up through the palm oil. In their passage through the tin the plates take a heavy coating, the surplus of which is removed by the pressure of the rolls in the grease-pot, the primary object of the hot palm oil being to keep the tin-coating fluid while this is being done. Less pressure is put on the springs forcing the finishing rolls together and a quicker speed is given to the rolls if a heavier coating of tin is required, and *vice versâ*.

It is obvious that the palm oil could not be allowed to remain on the tinned surface, and the plates are next removed to a cleaning machine, which is a device for pushing the greasy plates through a mixture having absorbent qualities. What is known as "shudes," a by-product of grain mills, or pink meal and powdered stone, is used. Finally, the finished plates are carried to the assorting room, where they are turned over singly and carefully examined for defects, the defective plates being rejected and sold at inferior prices. The plates are then first counted, then weighed, and packed in birch, elm, or other hardwood boxes, which are nailed down, and the plates are then ready for shipment.

* * *

TOBACCO PIPES.

(*See also* POTTERY).

(*a*) Among the branches of industry which have been a consequence of the introduction of tobacco, the manufacture of pipes has become of considerable importance. Immense quantities of wood, meerschaum, china clay, and pipe clay are annually converted into pipes, principally in England, France, Germany, and Austria; a smaller quantity being produced in Holland and Turkey. Wooden, china, and meerschaum pipes are made mostly in Germany and Austria, and among clay pipe producers England takes the first rank. Although the value of clay pipes is comparatively small, the enormous quantity in which they are made makes them an important product of industry to England.

Clay Pipes.—The principal pipe factories are located in Dorsetshire and Devonshire, where a pure variety of potters' clay is found in great abundance. It resembles kaolin in its character, although it contains a little less silica, and remains quite porous after baking. The clay is first freed of all impurities by levigation, and then undergoes repeatedly a process of kneading and curing in open tanks, exposed to the air, in much the same way as clay for other purposes is treated. After it has acquired the desired plasticity, it is divided into masses of about 50 lb. each, which are then given to the formers.

The first step in making a pipe is the formation of the stem in a metal mould. A small lump of clay is left attached to the rod, of which the cup is afterward formed. The rod is then pierced through its length with an oiled brass wire. Holding the pipe by the free end of the stem, the operator now imparts to the cup its external form by means of a copper mould, in which, if ornamental pipes are to be made, are engraved the designs. It is provided with a spring to open it automatically. The pipe then passes to a third operator, who forms the inside of the cup with his fingers, and establishes communication between the cup and the stem by piercing the separating wall with the brass wire. The pipe is now put aside to dry in the sun, after which it is ready for the oven. Three men finish 600–700 pipes a day.

Fig. 234 represents an oven used by English pipemakers. The fire A is located centrally in the oven. The heated gases circulate through the space B, formed by the walls of the oven and by the muffle C, which receives the pipes. The latter are introduced through the door E, and arranged in the position indicated, on shelves made of biscuit earthenware. An oven of this kind usually contains 2000 pipes. The pipes are generally baked for 8–9 hours.

Ordinary pipes receive no glazing of any kind, while some of the better class are painted and glazed. They are very porous, hence their tendency to adhere to the lips. To overcome this, the mouth ends are dipped in water containing a little pipe clay in suspension, and polished. By this means the pores of the clay are stopped. Pipes of better quality are covered with a mixture of soap, wax, and gum, and then polished.

Difficulty is occasionally experienced in holding the pipes in proper position in the oven. Some manufacturers fill the oven with fine sand after the pipes are in position. The sand fills all interstices and supports the pipes.

(*b*) The clay pipe, like the needle, has to undergo a large number of operations before reaching the state in which we find it in commerce. The manufacture of it requires much manipulation, and, despite the progress of mechanics, the machine has not been introduced.

For the manufacture of pipes, all clays are not equally suitable. Use is made of plastic and usually white clay, and sometimes of clay coloured by metallic oxides. Such clays are not met with in France in a sufficient state of purity, but are procured from the Belgian Ardennes.

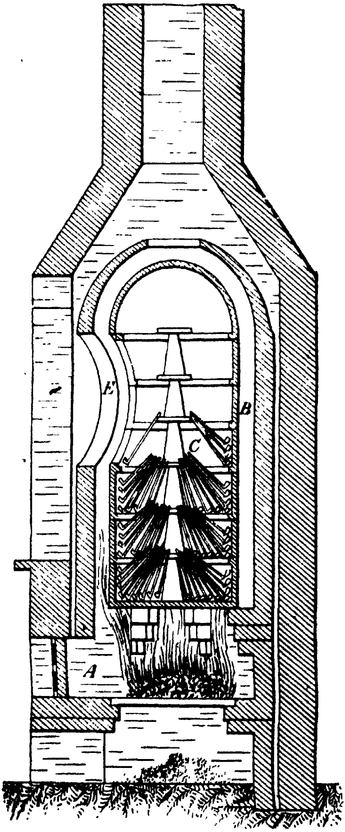


FIG. 234.

These clays always contain impurities, consisting of oxides, sand, fragments of rocks, etc., in variable proportion. The first operation that the material undergoes is consequently a cleaning, which is done partly by hand by children and is finished by a washing of the clay and allowing it to deposit in basins of large dimensions.

The second operation is the mixing of the earths in definite proportions. As each clay has a different property, the mixing of several kinds is necessary in order to obtain products that vary as to colour, hardness, etc.

This mixing is one of the principal secrets of the manufacturer, and an operation that requires no end of study before giving such a product as may be required by commerce. It is performed in pug mills actuated mechanically, and identical with those used in ceramics. The clay comes from the mill perfectly homogeneous and in a state of medium plasticity. It is then carried by an elevator to the rooms of the rollers in the upper part of the building. It is distributed in blocks over wooden tables, around which are seated 12–15-year-old children, who are called "rollers," and who take a piece of proper size in each hand and form it into a ball by rolling it on the table in different directions. Then, exerting a pressure with the hand upon a part of the ball, and giving it a backward and forward motion, they very quickly give it the form of a pipe whose bowl and stem are in the same axis. They have produced a "roll."

The roll made, they bend up the head of it slightly and place it alongside of them upon board. These boards, containing a definite number of rolls, are carried to the moulders.

The moulders' tools include a mould of one or more pieces (shown in Fig. 235), a compressor, a long needle, a steel knife, and a press.

The mould for simple pipes consists of two pieces of hollow steel, fitting together very accurately. For ornamental pipes it is of several pieces of chiselled bronze, held together in a steel case. The compressor is of steel, and is mounted upon a handle, and has the internal form of the bowl. The press is an ordinary vice fixed to the edge of the table (Fig. 236).

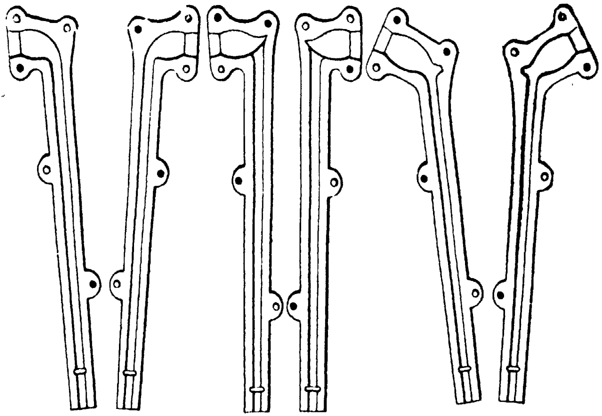


FIG. 235.

When the roll reaches him, the moulder places his open mould before him, and then taking a roll, the head of which he places upon a special support, he thrusts his needle into the centre of the tail of the roll, and pushes it up to the head, guiding it with two fingers of the left hand, so as to keep it exactly in the centre. An inexperienced person who should try to push the needle into the roll could not advance more than ½ in. without pushing it through the side, while the workman performs the operation in a few instants on pipes 15 in. long and 0 15 in. diameter in the thickest part.

This operation is performed in the same way upon pipes of all sizes.

The roll, thus pierced, and still containing the needle, is placed in the mould, and the latter is closed and put in the press. Then the workman takes his compressor and pushes it into the open part of the mould until he meets with the extremity of the needle that enters the bowl. The clay is thus compressed and the excess is removed by means of the knife. The moulder then removes his tool, opens his press, and then his mould, takes out the pipe and passes his knife over it, so as to remove the traces of the junction of the two parts of the mould, takes out the needle, and places his pipe upon a board alongside of him.

The pipes are arranged with care upon these boards, with their stems resting here and there upon small sticks or else upon very fine sand.

When these boards are full they are delivered to the finisher, who allows the pipes to harden a little before finishing them. The finisher begins by passing another needle into the stem, then scrapes off the seams, and removes the lines or scars formed on the stem by the various parts of the mould, and, with a copper tool, indents the figures that are to appear upon the pipe. He then arranges the pipes upon other boards, and leaves the needle in them so as to prevent a curvature of the stem during drying. The boards, holding a gross of pipes, are taken to the driers, whose temperature is very high.

When the pipes are sufficiently dry, workmen polish them with tools analogous to those used by burnishers, and which are manœuvred in the same way.

The pipes are then carried to other workmen, who verify them, reject the defective ones, and proceed to put the perfect ones in the saggers. These latter are terra cotta boxes, in which the pipes are arranged in circular beds, the bowls placed downward, and the stems united above by a defective stem in order to prevent them from getting out of place during carriage. When the saggers are full they are carried to special furnaces, and are superposed as in pottery furnaces.

In large manufactories, the operation of baking is the same as in potteries. The furnaces are in batteries of three; while one of them is being fired another is in process of cooling, and the third is being charged.

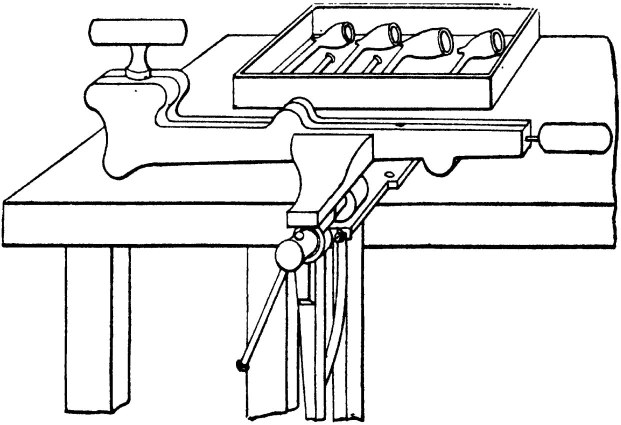


FIG. 236.

Each furnace bakes about 600 gross of pipes per day. The duration of the baking varies according to the clay, but it is at least 5 hours, and sometimes reaches 8–9.

After the baking, the furnace is allowed to cool for about 24 hours, then the saggers are taken out and the pipes are removed. The latter are then examined, and those that are well baked are polished anew

Although the pipe is finished, it has yet to undergo another operation before it can be used, and that is dipping. The object of this is to remove the porosity of the clay, which without this would stick to the lips. For this operation the pipes are taken and dipped, one by one, in a hot bath of soap water and wax, and then drained and dried.

The manufacture of the common pipe is at length finished; but, before being delivered to the trade, certain other operations are necessary: it must be labelled, and certain styles be wrapped up, and all must be packed.

The packing is done in wooden boxes filled with straw. The pipes are arranged alongside of each other in the boxes, and the intervals between them are filled with fine straw. The workmen must have some experience, for, if the packing is too tight the jolting that the box receives will be transmitted to the interior and break the pipes; and, if it is too loose, the pipes will strike against each other and pieces will be chipped off.

This operation must be carefully performed, as some boxes go to America, others to Australia, South Africa, and even to Northern Siberia.

All the operations above described are applied to the wholly white pipe. If the pipe is coloured, it necessitates several new operations. After the pipes have been baked, they are carried to the glazing room. The operators in this latter are usually women, each of whom has in front of her a series of cups containing liquid glazes of various colours, and each cup provided with a small stick. Each pipe is taken up by the operator, who, with the stick, puts a glaze upon it either in the form of dots or bands. It is in this way, dot by dot, that the pipes that are styled glazed are finished. These pipes are remarkable for the finish that they exhibit.

The pipes thus ornamented are arranged upon plates and put in furnaces raised to a high temperature, where they undergo a new baking that vitrifies the glazing. Then, after being labelled and wrapped up, they are packed.

So much for the manufacture of pipes properly so called. With such manufacture is incorporated an accessory one—that of moulds. The moulds are of steel and of bronze. Moulds for plain pipes are of steel, and those for ornamental pipes are usually of bronze, chilled internally. If the pipe represents a head or a complicated subject, this part of the mould is made in several pieces, in order to allow of the removal of the object. In this case the mould is always complicated, and is made with difficulty, for all the parts of it have to fit accurately and without leaving any seams on the figure.

The workmen who make these moulds must know how to sculpture very well, and must also possess some skill in the reproduction of complicated subjects, and know how to divide and arrange their moulds. These moulds are very costly. Some of them, which furnish true works of art, have cost as much as 120*l*. ('Les Inventions Nouvelles.')

(*c*) The clay of which these are made is obtained in Dorset and Devonshire, in large lumps, which are purified by dissolving in water in large pits, where the solution is well stirred up, by which the stones and coarse matter are deposited; the clayey solution is then poured off into another, where it subsides and deposits the clay. The water, when clear, is drawn off, and the clay at the bottom is left sufficiently dry for use. Thus prepared, the clay is spread on a board, and beaten with an iron bar to temper and mix it; then it is divided into pieces of the proper size to form a tobacco pipe; each of these pieces is rolled under the hand into a long roll, with a bulb at one end to form the bowl; and in this state they are laid up in parcels for a day or two, until they become sufficiently dry for pressing, which is the next process, and is conducted in the following manner:—The roll of clay is put between two iron moulds, each of which is impressed with the figure of one-half of the pipe; before these are brought together a piece of wire of the size of the bore is inserted midway between them; they are then forced together in a press by means of a screw upon a bench. A lever is next depressed, by which a tool enters the bulb at the end, and compresses it into the form of a bowl; and the wire in the pipe is afterward thrust backwards and forwards to carry the tube perfectly through into the bowl. The press is now opened by turning back the screw, and the mould is taken out. A knife is next thrust into a cleft of the mould left for the purpose, to cut the end of the bowl smooth and flat; the wire is carefully withdrawn, and the pipe is taken out of the mould. The pipes when so far completed, are laid by 2 or 3 days, properly arranged, to let the air have access to all their parts, till they become stiff, when they are dressed with scrapers to take off the impressions of the joints of the moulds; they are afterwards smoothed and polished with a piece of hard wood.

The next process is that of baking or burning; and this is performed in a furnace of peculiar construction. It is built within a cylinder of brickwork, having a dome at top, and a chimney rising from it to a considerable height, to promote the draught. Within this is a lining of fire-brick, having a fire-place at the bottom of it. The pot which contains the pipes is formed of broken pieces of pipes cemented together by fresh clay, and hardened by burning; it has a number of vertical flues surrounding it, conducting the flame from the fire-grate into the dome, and through a hole in the dome up to the chimney. Within the pot several projecting rings are made; and upon these the bowls of the pipes are supported, the ends resting upon circular pieces of pottery, which stand on small loose pillars rising up in the centre. By this arrangement a small pot or crucible can be made to contain 50 gross of pipes without the risk of damaging any of them. The pipes are put into the pot at one side, when the crucible is open; but when filled, this orifice is made up with broken pipes and fresh clay. At first the fire is but gentle, but it is increased by degrees to the proper temperature, and so continued for 7–8 hours, when it is damped, and suffered to cool gradually; and when cold, the pipes are taken out ready for sale.

Briar-root.—(*a*). The following note on the so-called briar-root pipes is from a report on the trade and commerce of Leghorn: Selected roots of the Heath (*Erica arborea*)—preference being given to the male variety—are collected on the hills of the Maremma, where the plant grows luxuriantly and attains a great size. When brought to the factory, the roots are cleared of earth, and any decayed parts are cut away. They are then shaped into blocks of various dimensions with a circular saw set in motion by a small steam-engine. Great dexterity is necessary at this stage in cutting the wood to the best advantage, and it is only after a long apprenticeship that a workman is thoroughly efficient. The blocks are then placed in a vat, and subjected to a gentle simmering for a space of 12 hours. During this process they acquire the rich yellowish-brown hue for which the best pipes are noted, and are then in a condition to receive the final turning and boring, but this is not done here. The rough blocks are packed in sacks containing 40 to 100 dozen each, and sent abroad, principally to France (St. Cloud), where they are finished into the famous G. B. D., or "Pipes de Bruyère," known to smokers in England under the name of "Briar-root pipes." ('Gard. Chron.')

(*b*) The root of the "Briar Ivy" is the substance most generally used in America for pipe making, it being selected for the purpose on account of durability, hardness, and the bright polish which it is capable of taking. It is found throughout the Southern States generally—the best qualities growing in Virginia—and is sent to the market in large pieces which vary in size from that of a man's fist to the dimensions of a good sized keg.

The above information was imparted to us by one of the manufacturers of pipes in the city, while wending our way from his office to the cellar underneath the factory, where the rough briar-root was stored. As we entered the last mentioned apartment, we noticed, heaped against the walls, the odd shaped pieces of the wood. Some had just been received, for a workman was busily engaged in throwing them into an oven which, heated by steam pipes, served to dry out all sap and moisture the wood might contain. In the middle of the cellar a circular saw was in motion, cutting the dry pieces into slices about 2 in. thick, which as soon as finished were received by boys and piled in regular heaps. From this underground apartment, the slabs are sent to a drying room on one of the upper floors, where they are kept heated at a moderate temperature for 6 months, during which time the wood becomes thoroughly seasoned.

Following our guide, we next entered the workshop, and were at length before a workman who, sitting on a bench in which revolved a circular saw, had at his side a pile of the slabs which we had already seen cut, down in the cellar. Taking one piece at a time, he pressed it against the blade, and in a few seconds it was divided into several smaller blocks of the shape of Fig. 237.

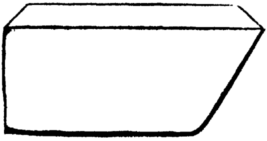


FIG. 237.

The blocks vary in dimensions according to the size of pipe to be made. Very little of the wood is wasted, the odd pieces being all worked up into stems or small pipes.

The blocks as soon as cut are passed over to the turners. Standing beside one of the workmen, we watched him as he placed the piece in the lathe chuck. A pressure of the boring tool, and the interior of the bowl of the pipe was excavated, then a part of the exterior was turned; and finally the block was reversed, and, in a few revolutions, the end for the stem completed. The entire operation did not occupy more than 10 seconds, the pipe, when thrown to one side, appearing as in Fig. 238. Still it was far from finished. It had to be carved into shape, and, to witness the process, we were conducted to another part of the room where the filers were at work. Each operative had before him a revolving disc, one side and the edges of which were cut coarse or fine, like files. This instrument removes the wood in either large or small quantities as may be desired. If the pipe is to be ornamented, the finer files are used to cut away minute portions. The workmen are all well skilled, and reproduce apparently intricate designs with wonderful accuracy. The most delicate work, such as faces, flowers, etc., are cut by hand.

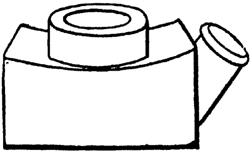


FIG 238

After the carving is completed and a hole is drilled for the stem, the pipe is thoroughly sandpapered by holding it against a revolving wheel covered with that material. This done, it is passed to the burnisher, where a brilliant polish is given to the wood by allowing it to rest against a rotary disc made of layers of chamois leather.

We next passed to the finishing room, where, seated at long tables, we found a number of workmen engaged in fastening to the pipes the metal tops and covers, together with the small bits of chain and bands which hold the stems and mouthpieces in place. The latter are manufactured from the tips of horns which are bought from the comb makers for the purpose. These tips are turned to the shape desired, holes are drilled through their length, and then they are bent into shape by the action of heat, and finally coloured black by a dye. When completed, they are carried to the finishing room and there attached to the pipes. Nothing further remains to be done but to pack the finished pipes in boxes, label and mark them, and they are ready for the market. ('Scient. Amer.')

Charcoal.—The use of charcoal in the preparation of pipe heads, a long time practised, has lately experienced many improvements, so that now pipes are produced remarkable for a deep black, lustrous appearance, and of very great durability. The material consists of a mixture of 2 parts best charcoal black and 1 part best black peaty earth, ground so finely that, when rubbed between the fingers no trace of granules is perceptible. 2 parts of this mixture are then united with 1 part of an equally well pulverised residuum of distilled cannel coal, containing still a portion of its bitumen, and the whole rubbed together thoroughly till all the three ingredients are uniformly combined. The mixture is then placed in iron boxes, in which are sunken moulds corresponding to the pipe heads, and while the boxes are then heated to the boiling point of water, stamps with rough surfaces are forced under hydraulic pressure into the openings of the heads, so that this process, united with the increased temperature, not only combines the carbonaceous mass into compact pipe heads, but also produces a smooth exterior, and at the same time a rough inner surface.

Meerschaum.—The following is a new process for preparing artificial meerschaum. Precipitates are prepared by means of a solution of soluble glass: (*a*) of silicate of magnesia, by precipitating it through a solution of sulphate of magnesia; (*b*) of silicate of alumina, by precipitating through a solution of alum; (*c*) of silicate of lime, by precipitating through a solution of chloride of calcium. All these solutions are diluted, 1 part salt being used for 10 parts water. In order to precipitate the solutions, the operation is performed at 20° C., except in the case of the silicate of alumina, for which the solutions have a temperature of about 50° C. (*d*) A solution of fused chloride of calcium (1 part to 15 of water) is precipitated at 15°-20° C. by a solution of sulphate of soda (1 to 15). The precipitate of sulphate of lime is first dried, and then freed of the larger part of the water that it may contain, by compressing it, and exposing it upon hurdles in a stove. Finally, it is totally dehydrated by heating it in a very clean iron kettle. The sulphate of lime thus prepared is in the form of a very fine and very white powder. It is carefully preserved in boxes that are kept in a perfectly dry place.

Into 33 lb. of water at 40° C. are put 19 lb. of precipitate *d* in 20 successive and nearly equal portions. The mixing should be done with much care and with rapid stirring. There are afterwards added to the mixture the following substances, weighed in advance: $7\frac{3}{4}$ lb. of precipitate *a*; $3\frac{3}{10}$ lb. of precipitate *b*; $5\frac{1}{2}$ lb. of precipitate *c*. All these precipitates should be mixed with water, and then the mass, which is in the form of a thin *bouilli*, is immediately introduced into a vessel through a No. 20 brass sieve, and thence into wooden boxes that rest upon large slabs of plaster covered with canvas, and about 4 in. thick. In about 15-25 minutes the mass may be detached from the sides of the frame by means of a blunt blade of brass, and the frame may be removed. The mass is left upon the slabs of plaster until it is sufficiently dry to be sawed into small blocks of various dimensions, according to requirements. These blocks are more thoroughly dried upon hurdles in a stove. Then they are worked with a knife or in a lathe, and are waxed and polished as in the case of objects made of genuine meerschaum. It should be remarked that, on introducing the hot mixture into the frame, care should be taken not to introduce air bubbles at the same time. Varying proportions of precipitates *a*, *b*, *c*, may be used. The larger the proportion, the harder and heavier will be the final mass.

Hookah.—Fig. 239 shows a hookah complete. A, a special meerschaum bowl; D, a turned piece of wood to fit bowl, and left long enough to go into cork; C, a good, sound, tight-fitting cork; T, a glass tube about ¼-in. diameter, fitted into bottom of D, and of such a length as to be about 1½ in. above bottom of water-bottle, vase, etc., G; T, a small piece of tube (glass) ¼-in. diameter, put through cork, and projecting about ½ in. under cork; S, the "snake" or tube (rubber $\frac{7}{16}$–½ in. diameter) attached to T; B, the mouthpiece. Water in bottle should always be about 3 in. below end of tube T; and should be renewed frequently as it soon gets discoloured. Fig. 241 is a section of Fig. 239. Fig. 240 shows pillar D adapted to an ordinary pipe, the mouthpiece being unscrewed, the bowl may be screwed on to face of pillar, instead of inserting whole stem of pipe, as sketched. Fig. 242 shows the hookah, as commonly used in India. A, burnt clay bowl; D, turned wooden pillar; G, coco-nut shell; B, bamboo mouthpiece. Water, of course, below entrance to mouthpiece. The letters refer to same parts in all the sketches. If air gets into vessel, and smoke does not come through tube in sufficient quantity, the top of the cork must be varnished, or have a coat of rubber varnish.

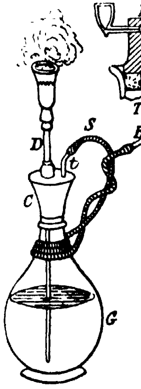


FIG. 239.

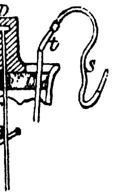


FIG. 240.

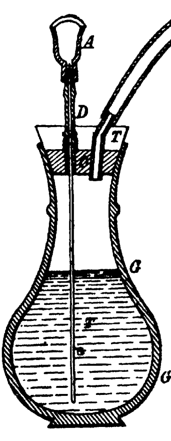


FIG. 241.

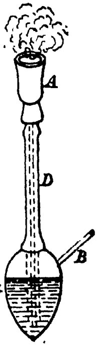


FIG. 242.

* * *

TOOLS,

HANDY, AND VARIOUS USEFUL RECEIPTS FOR CARE AND PRESERVATION OF TOOLS.

A Handy Punch.—Fig. 243 is a punch for punching holes, hot or cold. The drawing will explain itself. By making different sizes of dies and punches the same tool will punch as many sizes as you like. A is the die shown sectionally at C, to fit in hole D. B goes in the hole in the anvil. ('American Blacksmith and Wheelwright.')

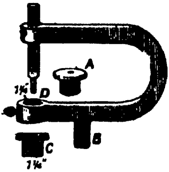


FIG. 243.

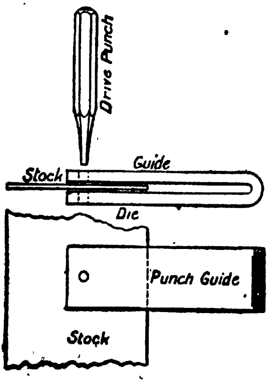


FIG. 244

Fig. 244 is a sketch of a little device for punching sheet metal by hand. Though it be an old device, yet it may be as useful to others as it has been to me, for, having no punching machine, either hand or power, I found myself confronted with a vast array of uncreated holes in a sheet-iron job. It looked like a case of drilling them or refusing the order. Neither of these alternatives appealed to my taste, so I doubled over a bit of steel, drilled a free hole through and through the ends, and my sheet-metal troubles were over. This tool is ludicrous in its simplicity and surely must be an old idea; but I have never seen it in use, and I offer it to those of my brethren who, like myself, have struggled long in the need of it. (Maurice R. Williams, in the 'American Machinist.')

Clippers for Cutting Bolts and Rod Metal.—These tools very readily clip or cut rod metal, only requiring the strength one man can easily exert, to effect this. They are found of great use in many workshops.

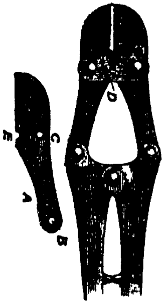


FIG. 245.

Fig. 247 is made as follows:—To make the blade take a piece of tool steel, ⅜ by 1¼, and forge as shown in sketch. For handles use 1¼ by ½; common iron will do. Put ½ inch hole in the blade, and use a steel bolt or rivet. Temper it and draw it to a blue. Use care in tempering the blade as only the cutting edge must be tempered. This size is suitable for

½-inch bolts and under. We have used two pairs of these clippers in the factory where I work for over a year, and they have given excellent satisfaction.

Fig. 246 is said to have been in regular use in a shop for 12 years, and cuts bolts up to ⅝ inch. The handles are 32 inches long, but for the heaviest work 36 inches is better.

Fig. 245, although resembling Fig. 246, works on a different principle, as will be seen. Take a piece of steel 1½ inch wide, ⅜ inch thick, 4 inch long and draw out as at A in the cut. Drill a hole, B, in the end, and another one 2½ inches from the other end, as at C. Make two cross pieces, D, 5⅛ inch thick, by 1 inch wide, with a hole in each end, and a $\frac{3}{16}$ inch hole in the centre for oil. Make a small roller ⅝ inch in diameter, and make a half-circular recess in each jaw as at E in the illustration. Half of the roller will then be in each jaw. Use ⅝ inch bolts in all joints. This bolt clipper will cut from ⅛ inch to ⅝ inch bolts when properly made. ('American Blacksmith and Wheelwright.')

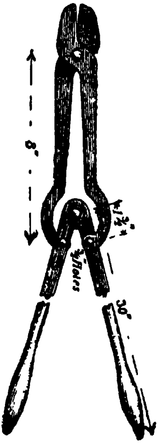


FIG. 246.

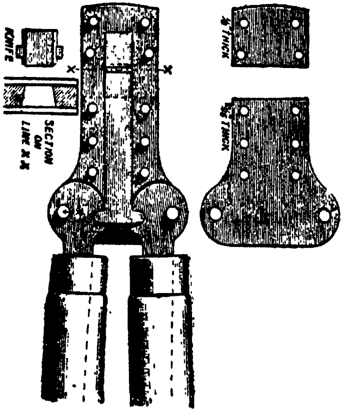


FIG. 247.

Dividing the Width of a Board into Equal Parts.—What is probably the best method of doing this, even when the board is to be divided into two equal widths only, is that illustrated in Fig. 248. It matters not what the width of the board may be, the method always applies. Lay the rule across the board diagonally, letting the ends come exactly at the edges of the board as shown. If the board is to be divided into two widths then a mark against the 6 inch mark on the rule, as at A, will do it. For three parts the mark would be against 4 inches and 8 inches on the rule, B B in the illustration, while for four parts it would be at 3 inches, 6 inches, and 9 inches on the rule, C C C on the drawing. With the rule as shown the divisions can also be sixths, twelfths, twenty-fourths, etc. For division into five, seven or nine parts, open the rule and place it to the 12½ inch, 14 inch, and 13½ inch marks respectively, when the divisions will be at the 2½ inch, 5 inch, etc. marks in the first case; at the 2 inch, 4 inch, etc., in the second; and at the 1½ inch 3 inch, etc. in the third case.

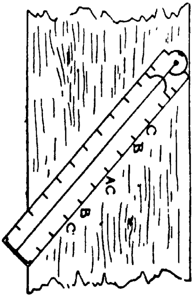


FIG. 248.

By this method it is easy to equally divide any board, no matter what the width is, into any number of parts, without the trouble of making exact calculations, or any waste of material.

Drilling Square Holes.—Suppose we want to drill ¼ inch square hole in any job. First take a piece of sheet steel of any convenient size and about ⅛ inch thick. Near the centre thereof drill a round hole small enough to be squared to ¼ in. File this out square, then harden and temper the template, which serves as a former to drill from, as represented in Fig. 249 of the annexed sketches. Fasten this piece on the job to be done by soldering, or any other convenient method, then cut with a twist drill a ¼ inch through the same or to the depth required. Next take a piece of ¼ inch 3-square steel of any convenient length, harden and temper one end of it, and put a centre in the other. Grind the hardened end as flat and square as possible, and give each side a little clearance, as represented in Fig. 250. The clearance has been purposely exaggerated in the drawing in order to show it more clearly. A, B, and C (Fig. 250) indicate the cutting edges of the tool. If the job is to be executed in a lathe, put a dog on the 3-square drill, and hold it in the usual way between the tailstock centre and the work, exerting a slight pressure backwards so as to keep it in the centre; then with the tailstock handwheel feed forward, as with an ordinary drill, but steadier.

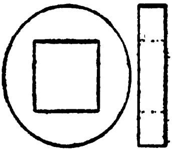


FIG. 249.

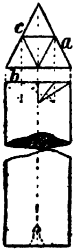


FIG. 250.

The resulting action of the 3-square drill within the square former plate, whilst it is rotating, is as follows:—The corners of the drill go into those of the former alternately, thus clearing out the right angles in the hole. If we allow $\frac{1}{16}$ inch clearance between the square former and the job, it is better for the 3-square drill, as the former does not take the sharp corners off the same where it is being used.

The writer has used this method, and has even drilled square holes small enough for watch keys, the square former in this case being only about ·02 inch thick. It is necessary that the length of each side of the 3-square drill should always be the same as that of the side of the square to be drilled. ('American Machinist.')

(*b*) To drill a square hole, the tool itself is the usual form of three-square drill, shown in Fig. 251; so that it will be seen that no special apparatus at all is required. Clamp or chuck this drill in its holder so that *it will wobble*, and you have the whole secret. Instead of making a round hole, as it undoubtedly will if tightly grasped, when loosely held it produces a square one. The tool mark, enlarged, is represented in Fig. 252. Evidently, the boundaries of the figure inclosed in the square are arcs of circles, having for their centres the corners. To see how this is produced, make a cardboard model representing a section of the drill, as shown in Fig. 253. Of course, it can be made of any size, bearing in mind that the points A, B, and C are equidistant. Now draw a square having sides equal to the distance between two points of the drill, as A C. Place the model upon this square, as shown in Fig. 254. The points A and C will plainly enter corresponding corners of the square, but there will be a space between the point B and the side D E. Now, retaining the point A in its corner, swing the model to the left, so that the point B will enter corner D (dotted-line arc). The point C will then pass to F, and the centre of the model G to H. The points A and B of the model then correspond with A and D of the square. Swing the model again, so that the points B C of the drill go to corners D E, and then lastly so that points C A go to E C. The next move will bring the model back to its first position, and it will have made an entire revolution. Now if we have marked the arcs described by the points, the outline of a figure similar to that represented in Fig. 252 will be found, and it will be clear that this may approximate closely to the square. The material in the re-entering angles on the sides of the figure is probably cut away by abrasion of the chips, after the drill has penetrated a short distance. The amount of "wobble" to give to the drill is measured by the distance of point B, Fig. 254, from side D E.

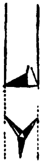


FIG. 251.

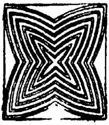


FIG. 252.

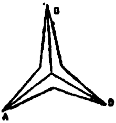


FIG. 253.

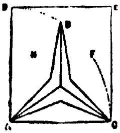


FIG. 254.

It will be seen that this principle can be extended considerably further; as, for example, to the boring of an hexagonal hole by a five-pointed or varied drill. This is easily tried with a cardboard model (Fig. 255). Begin, for example, by swinging the side AB on A as a centre, to A F. The distance B F represents the "wobble." Then, from this new position swing the point C a distance equal to B F; from this point D, and so on around the pentagon. The figure described by the sides will be found to be a hexagon. It is immaterial, the inventor says, whether the drill wobbles in the work, or the work under the drill. ('Scientific American.')

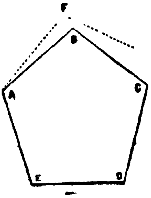


FIG. 255.

Extemporised Pipe-Wrench. It may not be generally known that an iron pipe, a round pipe, can be held or turned by an ordinary adjustable nut-spanner or wrench, if a file is inserted between the lower jaw and the pipe, as Fig. 256 shows. Any file will do, even a round one; in fact, a round one is best as tending to roll inwards and jam tight, when the strain comes. It is not intended to convey that this method should always be employed, for it is only a workshop wrinkle, useful to know when a proper pipe-wrench is not available.

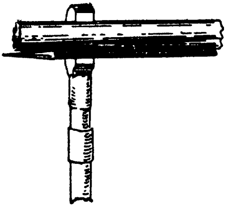


FIG. 256.

Handy Foot-Vice.—(*a*) The illustration, Fig. 257, shows a useful foot-vice, and which is easy to make.

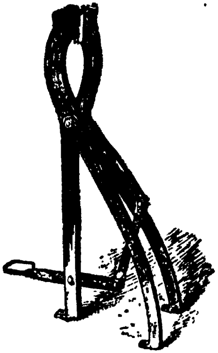


FIG. 257.

The main piece can be made with grooves of different sizes in its head for swaging caulks. Two legs are bolted on as shown, about a foot from the top. The treadle and other jaw are joined up as shown.

(*b*) Fig. 258 is a handy foot-vice which can be made as follows: Take an old light axle, cut off the spindles, stove up one end a bit, and flatten to $\frac{3}{4}$ by 2, which is plenty wide enough. I made one 3 in., but afterwards cut it down. Bend as shown in cut. Jump on lug same size of iron used; let extend out $1\frac{1}{2}$ in.; drill $\frac{7}{16}$ in. hole in same. Measure distance from top of anvil to floor and bend, allowing about $1\frac{1}{2}$ in. for play between vice and floor. Cut off 14 in. from where your bend comes, and flatten before you make it; it will be easier to handle in the bending. Bend the foot so your toe will hold vice in place, with heel on the floor. No need of much pressure. All that is required is to keep the shoe from getting away, while you do the rest.

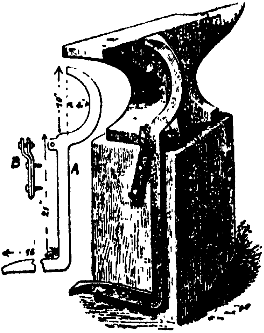


FIG 258.

For hanger I use $1\frac{1}{2}$ by $\frac{3}{8}$ double, and weld, leaving end open to receive the lug (as shown at B). You can attach the hanger to anvil block with two lag screws, $\frac{3}{8}$ in. by 3 in. You can hang this vice so it will free itself at just the proper distance from anvil without springs. If you can, make bends, and hang as shown at A in illustration. Bend hanger so it will put vice where you want it. The advantage this vice has over others is a solid foundation, which you cannot have with any other (no moving from one to the other). You can give caulks any slant you prefer. Remove bolt, and set away when not in use.

(*c*) Fig. 259 is a foot-vice for sharpening shoes. I have used it for more than ten years, and like it because there is more room between the anvil to hold the shoe to sharpen the heels if desired. I also make a swivel jaw, and use a spring to keep it open. I put a yoke over the peg to keep it in the hole in the anvil. ('American Blacksmith and Wheelwright.')

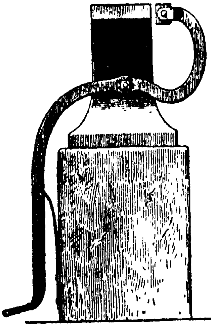


FIG. 259.

Keeping Engineers' Screw Taps in Order.—In an engineers' shop a tap is an indispensable tool, and, in fact, it is almost impossible to construct any mechanical appliance without the tap being used. The following hints on the proper care and use of the tap may not be amiss, as it is not always, save in the larger shops, that there is a tool department in which all small hand tools are stored and kept in order by a tool fitter. In a shop in which there is a toolroom, the fitter or machinist only requires to ask the size of the taps he wants when he will get a set of three taps, and, if necessary, a drill the standard tapping size, all being in good condition and ready for use. But in a small shop, where a toolroom is too expensive, and where the tools are kept in the store, a very different state of affairs prevails unless the storeman has some practical knowledge and takes an interest in the tools, and he has often plenty of other work besides this, so they are apt to get very little attention, and in time with wear and rough usage they are almost unfit for use. They may not be broken; but the cutting edge of the bottom threads may be so worn and chipped as to make it an impossibility to cut a thread with them. When you get a tap in this condition it is better to grind it up, grinding away all the worn portion and keeping the end of tap square; then tapering the end threads as they were at first, care being taken to grind more off the back than the cutting edge, otherwise the tap will not cut. About $\frac{1}{32}$ inch is enough clearance; if more than this is given it is apt to wobble about when starting, and there is also the danger when tapping tough metal of the cuttings getting behind the tap when backing out, and jamming it. This applies to the intermediate tap, the tapered tap being but little used where the hole is not clear through the metal. The plug tap, when the bottom threads are worn or broken, should be ground square on end till the bad part is removed, then the bottom edge bevelled to an angle of 45°. The tap will cut easier when ground in this way, as all the cutting is not being done by one edge; there is also less risk of breaking the thread. Of course this will not tap to the very bottom of a hole; but it is seldom that a hole is tapped to the bottom, and when it is done we often find that the bottom thread of the tap has been left there. It is much easier starting a tap in a hole if the edge of the hole has been left sharp, and not slightly countersunk, as is sometimes done to prevent the top thread being raised above the surface when a stud is screwed in. This can be done as easily with a chisel or a drill after the hole is tapped. Oil should not be put on the tap till it has a good hold of the metal, as there is less friction with the oil, and more force has to be exerted to start the tap. A common device for keeping the tap square when tapping is to run a faced nut on the tap, and when the tap is started to run the nut down to the surface, when it will at once be seen whether the tap is square, and holding the nut in position when the tap is square, and running the tap through it. This is only necessary at first, as, after some practice, the nut need only be tried down for two times to test the squareness of the tap. When tapping a tough material, such as wrought iron and mild steel, it is much easier done if the tap is given a half-turn back every three or four turns. This eases the tap, and breaks the chips, which are apt to curl up and jam the tap. This does not apply to the tapping of nuts on a machine, as the tap used for this is tapered all its length and takes but a light cut, and is not like an intermediate tap doing all the cutting with two or three threads. When a nut is tight for a stud, a piece of tin run through the nut with the tap will make it easier. ('English Mechanic.')

Making a Small Anvil.—The sketch, Fig. 260, shows how to make a small anvil. Take a piece of cast steel 2 inches by 6 inches, then take a bar of iron 2 inches square and upset and scarf to shape as at A A, Fig. 261. Make a good heat on both steel and iron and put together as at B B. Lay steel on the anvil and hold iron on top of it, and let the helper strike on the end of it; and also weld down the scarfs well at B B with the fuller. Next forge to shape and draw out as per dotted lines C C. That done, cut off your bar of iron at D and fuller in recess as at E. Then turn up the ends in direction of arrows at G G, and dress up base to proper shape. Dress up face and horn, and drill or punch your holes and temper.

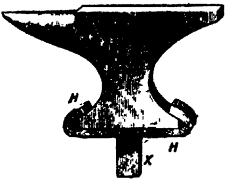


FIG. 260.

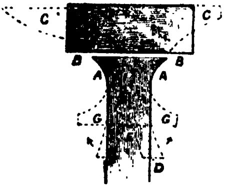
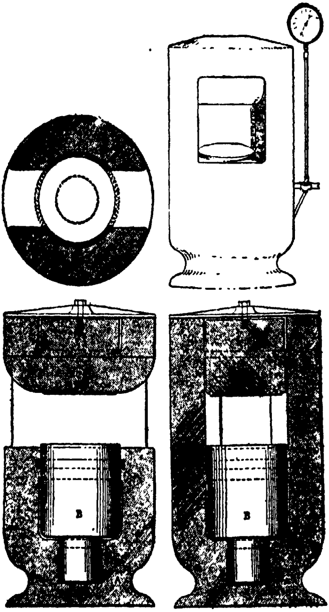


FIG. 261.

H (Fig. 260) is a base for sliding anvil into. When doing light forging on it, the shank X fits into large hole in big anvil, or to fasten in the vice or in any block of wood. The lower illustration shows the anvil in base. Such a tool can be used daily. I often wonder how I kept shop without it. Besides using it for welding very small ferrules and standing it on the forge 12 inches from the fire to weld very light iron on, I use it for backing up nuts that I want to split off the bolts, to back up rivets on a buggy top, or in a waggon box and various other things too numerous to mention. But the most use I have found for it is during harvest time, to repair reaper knives. I lay my sickle on a block at one end, and on this small anvil at the other, and punch out the old rivets and put on new knives and rivets much handier and in less time than any other way I have ever tried. ('American Blacksmith and Wheelwright.')

A Shop-made Tap to Cut a Left-hand Thread.—It frequently happens that a smith has to cut a left hand thread when he has not any proper tap to do the work. The following is a simple method of making one that will answer all purposes :—

Forge a piece of steel out to three-cornered shape of the right size for the hole to be tapped. An old three-cornered file, softened, may be used. Then take a piece of linen thread and wind around it in a left-handed direction, having the turns the same pitch as the thread that is to be cut. Now take three-cornered file and cut out threads in the corners of the tap, being guided by the linen threads as to the proper place to file, after which temper in the following manner:—Heat steel in a charcoal fire to a cherry red, then dip perpendicularly in clean water that has the chill taken off it; brighten tap along the sides, and then lower as follows: A piece of tube about half the length of the tap and about twice or three times its diameter, having its thickness about the same as the diameter of the tap, should be heated to an even cherry-red; take the tap in a pair of tongs whose jaws have been warmed and pass it back and forth (revolving it) through the tube until a brown colour appears. Then quench it in warm water. Should either end of the tap lower too rapidly, cool it by a slight application of oil. ('American Blacksmith and Wheelwright.')



FIGS. 262, 263, 264, 265

A Simple Hydraulic Press.—The four illustrations here given, Figs. 262, 263, 264, and 265, afford particulars of a hydraulic press which seems to have been reduced to its simplest elements. The press proper consists of three principal parts only—the frame A, ram B, and the platen C; the usual rods with nuts, washers, etc., being dispensed with in favour of a construction which makes the base, the uprights, and the top of a single piece, which is bored at the top as shown in the drawing, to receive the platen C, at the bottom where the ram B fits, and faced off on the upper surface of the openings for the platen C to form a seat, as shown in vertical section. The plate on top of the upright is simply to hold the platen in place when pressure is removed from it. The stem on the lower part of the ram is turned to fit the bored seat in the frame by means of which the ram is accurately guided, and the drawing therefore shows absolutely all there is of the press, it being adapted for use in connection with any suitable force-pump. It is apparent, of course, that this construction secures great rigidity, and we understand the press is used particularly for hobbing dies used in jewellery manufacture, and for similar purposes where a hardened hob is by great pressure simply pressed into the die cold to form the impression. ('American Machinist.')

Soft Hammers.—There is scarcely anything about a machine-shop that has such a wide use as the soft hammer, and yet it is surprising to note the crudeness of these hammers in some shops. No one hammer could be recommended as the ideal hammer for all shops, for the reason that the class of work varies. A piece of lead held in the hand would be sufficient to drive anything up into place in some shops, while in the erection of heavy machinery it is necessary to hit a blow so heavy that a large chunk of lead at the end of a long handle would be insufficient to move it. We are, therefore, obliged to hold the hammer against the work and bump it into place by the use of a battering-ram. Three grades of hammers will usually cover everything, from the lightest to the heaviest work. Hammers for light work are made of Babbitt metal about 6 in. in length, and are cylindrical when cast. After a short usage, the ends become battered up. This style of hammer is most satisfactory when made in three sizes, the smallest being 1¼ in. in diameter, the next one 1¾ in., and the largest 3 in. in diameter. They are all the same length, about 6 in. or so being the convenient size.

When these hammers become battered up they are melted and recast in a cast-iron mould, Fig. 266. A, B, and C are the cylindrical openings for the different sizes. The mould is set down on a board which is covered with clay, and each one of the recesses is filled up with molten Babbitt. As soon as the metal sets, the mould is opened, and is then ready for another set of castings. There is, perhaps no hammer that is more convenient for light work, such as sewing machines, etc., than the smallest of these sizes.

On heavier work we are enabled to strike a blow of sufficient force with the largest one of these sizes. If we were to put a handle on the hammer, we would be able to strike a much harder blow; thus we find in some factories the lead hammers shown in Fig. 267. The handle is made of hard wood. They are cut off in large quantities from straight sticks which have been shaped up at the planing mill. A mould is arranged to receive this wooden handle, and then the Babbitt is poured around it. These hammers are usually made in one size. The handle being made of wood, one is able to get a very good hold with greasy hands. After the hammers have become battered up, they are thrown into a pot and the Babbitt is melted off. The handles being cheap, are thrown away and new ones are used in their place.

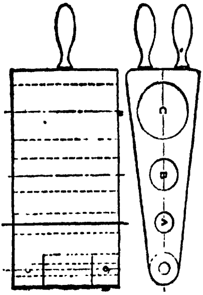


Fig. 266.

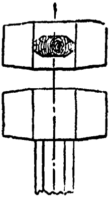


Fig 267.

For very heavy work the hammer, Fig. 268, is very convenient. The handle is made of $\frac{1}{2}$-in. round iron, and is about 2 ft. long. A mould is arranged to receive this handle, and into it the Babbitt is poured. With this hammer one can strike a heavy blow, and, in addition to this, one can place this hammer against a heavy piece of work and bump a battering-ram up against it. This is not true of the other two classes of hammers just spoken of. The hammer in Fig. 267, for instance, will crush very quickly when subjected to this treatment. These hammers, Fig. 268, last a long while, and when they become battered they are used in connection with the ram, as already stated. These hammers can be pounded down so as to form a flat cake 5 in. in diameter, and are still satisfactory for this class of work. The hammers are thrown into the Babbitt ladle, and when the Babbitt is melted out the handles are used over again for new hammers. ('American Machinist.')

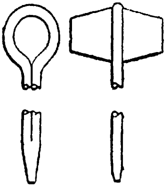


FIG. 268.

A Useful Tool for Cutting Half-round Grooves in Wood.

Fig. 269 shows this tool, which can be home-made. It is simply a wooden handle on the end of which is a piece of brass tube C, secured by the pin D. The handle should have a rounded club end, as the tool is pushed with the hand, no mallet being required. The rings marked at B is where the left hand holds the tool, the forefinger of this hand being used as a guide on the edge of the work. An edge at the opening of the tube A is given by filing the brass tube inside, not outside. It will be found that little skill is required in the use of this tool, and the results will be superior to a carver's gouge. In cutting an oil channel on a machine bed pattern the corners can be mitred if the end of the tube C is cut at an angle as shown by dotted line.

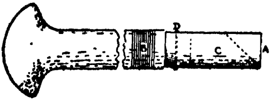
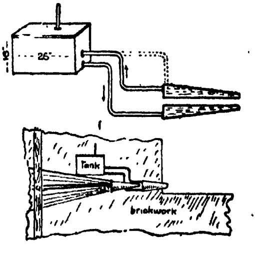


FIG 269.

Fixing a Water-Tuyere or Tue-Iron.—A smith, once he has used a water-tuyere, is seldom afterwards satisfied with the dry back style to his forge fire. The water tuyere has a section as shown in Fig. 270, it much resembling a large hollow sugar-loaf, with a tube running through its length. Between the tube and the outer case is a water space as indicated. It is not possible to have the space sealed and steam tight, for, in this state, it would soon explode when heated; nor is a simple steam pipe sufficient, as with only this the tuyere would soon be boiled empty and dry. It has therefore to be connected up to a cistern or tank by a pair of circulating pipes, like a range boiler, and if the tank is of fair size the water will not reach boiling point, and the loss by evaporation will be very small. It may be considered that the tank should



FIGS. 270, 271.

hold 20 gal., for best results, and the circulating pipes should be as low in it as possible, for when the water in the tank gets below either pipe there will be no circulation. The circulating pipes may be ¾ in. or 1 in., but not less than ¾ in. In the sketch (Fig. 270), is shown an alternative way of running the flow pipe from tuyere to tank, but whichever way may be adopted this pipe should be connected to the highest possible point of the tuyere. Fig. 271 shows the tuyere in position. It may be fixed with or without a cast-iron breast (at the nose or front of it), though it is always best to use one. If used without a breast the tuyere should be fixed in the forge face with fire-bricks bedded in fire-clay, and should stand about 3 in. out on the hearth side. If the ordinary water supply is hard water, with lime in solution, it will be found best to use rain or clean pond water for filling the tanks.

Marking Tools.—A correspondent to the 'Inland Printer,' states that the following is a plan adopted in a large trading concern:—First have a rubber stamp made with white letters on a black ground; then make up an ink to use with this stamp as follows: Ordinary resin, ½ lb.; lard oil, 1 tablespoonful; lampblack, 2 tablespoonfuls; turpentine, 2 tablespoonfuls. Melt the resin, and stir in the other ingredients in the order given. When the ink is cold it should look like ordinary printers' ink. Spread a little of this ink over the pad and ink the rubber stamp as usual, and press it on the clean steel—saw blade, for instance. Have a rope of soft putty, and make a border of putty around the stamped design as close up to the lettering as possible, so that no portion of the steel inside the ring of putty is exposed but the lettering. Then pour into the putty ring the etching mixture, composed of 1 oz. of nitric acid, 1 oz. of muriatic acid, and 12 oz. of water. Allow it to rest for only a minute, draw off the acid with a glass or rubber syringe, and soak up the last trace of acid with a moist sponge. Take off the putty, and wipe off the design with potash solution first, and then with turpentine, and the job is done. (*And see* ETCHING.)

Tools, Keeping in Condition. The following recipes are recommended for preventing rust on iron and steel surfaces:—

1. Caoutchouc oil is said to have proved efficient in preventing rust, and to have been adopted by the German army. It only requires to be spread with a piece of flannel in a very thin layer over the metallic surface and allowed to dry up. Such a coating will afford security against all atmospheric influences, and will not show any cracks under the microscope after a year's standing. To remove it the article has simply to be treated with caoutchouc oil again, and washed again after 12-24 hours.

2. A solution of indiarubber in benzene has been used for years as a coating for steel, iron, and lead, and has been found a simple means of keeping them from oxidising. It can be easily applied with a brush, and is easily rubbed off. It should be made about the consistence of cream.

3. All steel articles can be perfectly preserved from rust by putting a lump of freshly-burnt lime in the drawer or case in which they are kept. If the things are to be moved, as a gun in its case, for instance, put the lime in a muslin bag. This is especially valuable for specimens of iron when fractured, for in a moderately dry place the lime will not want renewing for many years, as it is capable of absorbing a large amount of moisture. Articles in use should be placed in a box nearly filled with thoroughly-slaked lime. Before using them rub well with a woollen cloth.

4. The following mixture forms an excellent brown coating for preventing iron and steel from rust: Dissolve 2 parts crystallised iron chloride, 2 antimony chloride, and 1 tannin in 4 of water, and apply with sponge or rag, and let dry. Then another coat of

paint is applied, and again another if necessary, until the colour becomes as dark as desired. When dry it is washed with water, allowed to dry again, and the surface polished with boiled linseed oil. The antimony chloride must be as nearly neutral as possible.

5. To keep tools from rusting, take ½ oz. camphor, dissolve in 1 oz. melted lard; take off the scum and mix in as much fine black-lead (graphite) as will give it an iron colour. Clean the tools and smear with this mixture. After 24 hours rub clean with a soft linen cloth. The tools will keep clean for months under ordinary circumstances.

6. Put 1 qt. freshly-slaked lime, ½ lb. washing soda, ½ lb. soft soap in a bucket and sufficient water to cover the articles; put in the tools as soon as possible after use, and wipe them up next morning or let them remain until wanted.

7. Soft soap with half its weight in pearlash, 1 oz. of mixture in about 1 gal. boiling water, is in everyday use in most engineers' shops in the drip-cans used for turning long articles both in wrought iron and steel. The work, though constantly moist, does not rust, and bright nuts are immersed in it for days till wanted, and retain their polish.

8. Melt slowly together 6–8 oz. lard to 1 oz. rosin, stirring till cool; when it is semi-fluid it is ready for use. If too thick it may be let down by coal-oil or benzene. Rubbed on bright surfaces ever so thinly it preserves the polish effectually, and may be readily rubbed off.

9. To protect metals from oxidation, polished iron or steel for instance, the requisite is to exclude air and moisture from the actual metallic surface; therefore, polished tools are usually kept in wrappings of oil-cloth and brown paper, and, thus protected, they will preserve a spotless face for an unlimited time. When these metals come to be of necessity exposed in being converted to use, it is necessary to protect them by means of some permanent dressing, and boiled linseed oil, which proves a lasting covering as it dries on, is one of the best preservatives, if not the best. But, in order to give it body, it should be thickened by the addition of some pigment, and the very best, because the most congenial of pigments is the ground oxide of the same metal, or in plain words, rusted iron reduced to an impalpable powder, for the dressing of iron and steel, which thus forms the pigment or oxide paint.

10. Slake a piece of quicklime with just water enough to cause it to crumble in a covered pot, and while hot add tallow to it and work into a paste, and use this to cover over bright work; it can be easily wiped off.

11. Olmstead's varnish is made by melting 2 oz. rosin in 1 lb. fresh sweet lard, melting the rosin first, and then adding the lard and mixing thoroughly. This is applied to the metal, which should be warm, if possible, and perfectly cleaned; it is afterwards rubbed off. This has been well proved and tested for many years, and is especially well suited for planished and Russian iron surfaces which a slight rust is apt to injure very seriously.

◆

TORTOISESHELL.

(*a*) THIS substance is not obtained from the animal commonly known as a tortoise, but forms the shell of the hawk's-bill turtle—a turtle that frequents the seas of the West and East Indies and some other tropic seas. There can be no doubt that with the greatly increased demand and price that now exists, the shells of other species of turtle are pressed into use, and this is made more possible by the fashion in these goods admitting of plain orange-coloured shell being used as freely as that which has the beautiful brown mottling of the true shell. Some idea of the value of the substance can be obtained by the fact that a single hat-pin—a round knob of plain yellow shell on a silver-gilt pin is now worth one pound, while a good comb, which ladies wear in their hair, may fetch anything from 5*l*. to 20*l*. This is for shell goods only, without jewelled or gold enrichments.

The hawk's-bill turtle has a shell which consists of a number of plates, overlapping at the edges like tiles on a roof, thirteen full plates on the middle of the back with 25 smaller ones around the edge. In the trade these are known as blades, and are mottled in colour. The under or belly plates are plain yellow. None can be considered true shell, as in substance the material more nearly approaches horn. To detach the blades from the bony base fire-heat is employed, which causes the shell to come away, a thin knife completing the operation.

In working tortoiseshell the processes somewhat resemble those adopted with horn. Boiling water will soften the material, but some care is needed, as too long a treatment spoils the colour. A little salt in the water does much to prevent injury from this cause, though some care is again needed, as a strong solution of salt makes the shell brittle.

A remarkable property possessed by the shell is that of "welding," it being possible to join two pieces by simple pressure if they are suitably prepared. Two edges are well bevelled, scraped clean, then pressed together in a small press and put into scalding water. From time to time the press is tightened up, and in a few hours the joint is complete and sound without injury to the colours or texture of the shell. Another method is adopted with tongs, no water being used. The ends to be joined are prepared as just stated, then several folds of damp linen are put on each side, and this is then clipped with a pair of flat-ended tongs which have been previously heated sufficiently hot to colour writing-paper yellow. They are then put in a vice and tightened up moderately firm and left to cool. Here again care is required to prevent excess of heat having an ill effect. It will deepen the colour, sometimes to blackness.

Comb-making is practised with this material as with horn, every care being exercised to prevent waste of material. With objects requiring the shell to form a rim, the shell lends itself to ingenious treatment. A narrow piece of shell is taken and a slit is cut in it, then, after the shell has been softened, the edges of the slit are carefully pulled from each other until they make a circle, or ring. This treatment somewhat prejudices the strength of the material, but it remains strong enough for all ordinary purposes, though not so to the extent that old articles have which were cut out of the solid.

Tortoiseshell is moulded for boxes or hollow goods by being cut to a suitable size in the flat, then placed in position on or in the mould, which is then lowered into boiling water. In about half an hour, the block can be pressed gently into the mould, carrying the shell with it. If a deep design is intended, this is not pressed out at once, but is obtained by using two or more moulds, each one of increasing depth. After moulding, the article can be finished on the lathe. Where cheapness or economy is requisite, the mould can be lined with pieces of shell, the edges of which are bevelled, lapped and prepared as for welding. Or a flat plate can first be made by welding pieces together. Even dust and chips of shell can be used, these being softened and pressed together, or moulded, making a real tortoise-article but of inferior finish and appearance, the substance being nearly opaque. This plan may serve for working in the less important parts of good shell articles. Occasionally, colouring or adulterant materials are added when working up fine stuff.

Tortoiseshell can be used as a veneer for a wooden foundation, as with boxes, etc. The plates are reduced to uniform thinness, then glued on as with other kinds of veneer. To bring up the best effect and brilliancy of the shell and to hide the wood, fish-glue is used, coloured as may be desired.

To inlay tortoiseshell with mother-of-pearl, gold, silver, etc., the ornamental pieces are arranged on the plate of shell and then pressed in. The operation is as follows:—First, make a bed of tortoiseshell filings within the mould or press, and place a sheet of thin paper over these, place the shell-plate (with the ornamental pieces ready upon it) on to the paper, then steadily lower the top die-plate until it presses on the plate, plunge the whole into boiling water for an hour, and then examine to see that none of the ornaments are displaced. Close the press and put in the boiling water again, and after a short time bring heavy pressure to bear, and while under this pressure plunge into cold water. It will be found that the ornaments are perfectly inlaid and the surface only requires smoothing and finishing.

(*b*) So far no successful method of melting tortoiseshell has been discovered, and the shaping is therefore confined to cutting, welding and moulding. Cementing is sometimes done, but not where welding is possible. A cement is as follows:—Take 30 parts shellac and 10 parts mastic, dissolve these in 125 parts of 90 per cent. alcohol, and add 2 parts turpentine.

(*c*) In making tortoiseshell combs two are cut out of one strip to save waste. This is done by making a deep zig-zag cut down the centre of the strip, so that when the two parts come asunder the cut is found to give each piece a set of teeth. It is necessary to pull the two pieces apart as soon as possible or they will stick (weld) together in places. Round knobs and ornaments are moulded after the shell has been heated. Moulding has to be done slowly, but is quite successful. To polish tortoiseshell it is first scraped then polished with charcoal dust and water applied with a woollen cloth quite free of grease. This is followed by whiting and water, and finally hand-rubbed with whiting or rotten-stone. Another method is, after scraping or rubbing with finest sand-paper to get a smooth surface, to next use charcoal powder and water, then dry rotten-stone, finally with soft wash-leather and sweet-oil. Or a final finish can be made with nitrate of bismuth, hand rubbed.

(*d*) A cement for mending tortoiseshell is made by putting some Canada balsam in an oven and heating it until, when allowed to cool, it becomes hard. When required for use remelt it by gentle heat and apply to the surfaces to be joined. Wire the parts soundly together and leave 24 hours. On removing the wire any excess of balsam can be removed with a sharp knife.

Imitation Tortoiseshell. *Horn.*—(*a*) Mix up an equal quantity of quicklime and red lead with soap-lees; lay it on the horn with a small brush, in imitation of the mottle of tortoiseshell; when it is dry, repeat it two or three times.

(*b*) Grind 1 oz. of litharge and ½ oz. of quick lime, together with a sufficient quantity of liquid salts of tartar to make it of the consistence of paint. Put it on the horn with a brush, in imitation of tortoiseshell, and in three or four hours it will have produced the desired effect; it may then be washed off with clean water; if not deep enough it may be repeated. If required a deeper colour can be given to the mottlings by going over the parts with red, brown or black colours mixed with whiting and water.

(c) Take a piece of lunar caustic about the size of a pea; grind it with water on a stone, and mix with it a sufficient portion of gum arabic to make it of a proper consistence; then apply it with a brush to the horn in imitation of the veins of tortoiseshell. A little red lead, or some other powder mixed with it, to give it a body, is of advantage. It will then stain the horn quite through, without hurting its texture and quality. In this case, however, be careful, when the horn is sufficiently stained, to let it be soaked for some hours in plain water, previous to finishing and polishing it. Pieces of horn are united together to form one large piece by being softened at the edge by boiling water, and then pressing them together powerfully while surrounded by boiling water.

Imitation Tortoiseshell is now chiefly made with celluloid. Take some pasty celluloid and mix with it some brown aniline dye (soluble in spirit), and with another proportion some yellow dye of the same kind. Work these doughs (or one of them only if desired) into some nearly colourless celluloid, and if done carefully streaks and patches of colour in the mass will be obtained similar to tortoiseshell. Practice is required to get the best effect in mixing the coloured and colourless materials.

* * *

TRANSFERS.

HOW TO USE.

TRANSFERS are now widely used in many trades, for decoration, trade marks, and the like, the transfer being practically non-detachable (which makes it different to a paper label), and having the appearance of being printed or painted direct on the article it is affixed to. Decorators, japanners, and coach-painters use transfers largely, as also do makers of bicycles; while the transfer is now being recognised as superior to paper labels for bottles.

Bronze and gilt designs, as the trade marks on bicycles and japanned goods, are printed on very thin tissue paper, and are affixed direct with an adhesive substance; while the more decorative transfers, in colours, are on thick paper, so that the design is scarcely visible. The best goods of this kind have an outline of the design printed on the back of the paper, corresponding with the design of the transfer, and this enables the operator to fix the transfer in position without trouble. When this outline is not printed the paper should be held up in a strong light to enable prominent tally marks to be pencilled on. In most cases the transfers are sold by the printers in sheets only, the number of separate designs on each varying, of course, according to their size. Some transfers do not appear transparent when held up to the light, but are coated or backed with gold or silver, which in some cases gives the impression that they are metal transfers. This metallic backing forms a protective coating to the design, and it also prevents the colour of the ground—i.e. the article the transfer is going on—interfering with or obscuring the colours of the transfer. For instance, if a transfer is in transparent colours and is going on a very dark ground, the metallic backing is required, while on light coloured bodies the transfer can have a white backing; if the transfer is going on a white ground, or a very light one, the backing is not usually needed.* In the same way, when a transfer consists chiefly of gold, bronze, or other metallic material (as trade marks commonly are) no backing is needed, as the design of the transfer is then opaque. These points require consideration, as the backing makes a difference to the cost.

A well-known American firm of transfer printers issue the following notice: "Transfers, when just completed, are fresh and delicate, and the colours at such times, not being thoroughly dry, are easily affected by the cleaning substance. The best precaution is to take as many transfers as are needed for immediate use and place them between a newspaper or catalogue, in an oven where the heat is about 110° F., leaving them there from 12 to 24 hours, at which time the oil in the colours will be thoroughly dry." This is of special importance where the designs have been printed in accordance with special requirements, such as name tablets or colour designs, to suit special articles. Stock goods do not require this drying process.

A good ground or foundation is very necessary for best results with transfers. With japanned work the transfer should not go on until after the first coat of clear finishing varnish is hard, and, on painted goods, a coat of varnish should follow the transfer if it is to be permanent. Woodwork that is stained and varnished should have the transfer put on just before the last coat of varnish, while in certain cases, with all goods, the transfer is put on last of all, and a little varnish laid over the transferred design only.

Much cheap marqueterie work which is supposed to be an inlay of decorative woods in ornamental design, is done with transfers. The transfers themselves are works of art and are expensive, but not nearly so costly as real wood inlay. They are applied when the polishing of the groundwork is practically finished, a coat of transparent polish following the transfer.

It is difficult to enumerate the great number of uses to which transfers are now put. Japanned ware, whether metal, wood or pulp, makes a great demand in itself; polished wood ware, leather, glass (bottles are even labelled with transfers), leather, celluloid and composition goods, toys, fancy goods of every kind, and even such goods as ornamental candles and wax goods can be decorated in this way. In fact, any surface which is hard, clean, and not too porous, will take transfers. It is not absolutely necessary that all transfers should be coated with varnish or French polished; but in all cases where it can be done, such treatment is advised, as it tends to keep the transfers clean, prevents accidental scratching, protects gold decorations from tarnishing, and, in the case of imitation inlaid woods, tends to add depth and solidity. The transfers must be cut from the sheet with a margin of white paper around the design, and tally pencil marks should be put on the back, and corresponding marks on the article to be decorated. Place the transfer, face (design) upwards on a large sheet of paper, then with a flat camel-hair brush apply the transfer varnish in a thin coat. Do not have the brush heavily charged with the varnish, as the coat should be put on as near as possible of even thickness, without going over the same place 2 or 3 times. Let the varnish go over the whole of the paper, not on the design only. When the varnish is "tacky" (dried to a very sticky state), lift the transfer carefully, and then, just as carefully, place it where it is required. Press it down well with a soft pad, pressing in the centre first, and working outwards towards the edge. If this is not done, one or more air bubbles may be formed, with bad results. Transfers with stiff paper backs may not lay well, in which case slightly damp the back with a sponge moistened in clean warm water, then press well down again to force the design against the surface. A rubber roller, as used by photographers, will be necessary in the case of large designs, and if several transfers are being handled. It is essential that the transfers shall be in close contact with the surface in every part. Allow them to remain at least ½ hour, and if possible, longer, as the picture then adheres more firmly to the surface. When the transfers are thus ready for the paper to be removed, sponge over the paper backs with warm water, and then press or roll the paper again. Sponge again, and soak with water freely until there is a certainty of the paper coming off quite easily. At a suitable moment this can be tried by lifting a corner. The paper is peeled off, starting by lifting a corner, and no attempt should be made to slide the paper off, as is done with children's toy transfers. With a clean damp chamois leather dab up the surplus moisture and allow the transfer to dry. When dry, any varnishing or polishing that is intended may be done.

If the work is hastily done it will be found that when the transfer has dried (before varnishing or polishing) a whitish film will appear around the design. If the article is to be French polished, this is of little consequence, as what may be left after sponging with water will usually disappear when wiped over with raw linseed oil before applying the polish. Where an oil varnish or gold size has been used as a fixative, and oil varnish will be employed as a finish, the white film may be removed by sponging with benzene, or turpentine mixed with a small amount of water, any surplus left on the face of the design being afterwards wiped off.

When affixing the transfers to painted or varnished surfaces, the fixative, i.e. the transfer varnish, may be made of a good quick-drying oil varnish, thinned with turpentine, so that it will become "tacky" in 10 to 15 minutes. On goods which are French polished, a spirit varnish may be used. Where there are pearl or gold inlays, a transparent varnish is best. The fixative for enamel-glaze or for wax, is good quality gelatine dissolved in hot water; or pale gold size may be substituted. For affixing transfers to the japan of coach-builders' work, a plan sometimes adopted is to press the transfers on to one of the coats of varnish on the work, before it is dry, using no other fixative.

* * *

TYING AND SPLICING.

(*See also* NETTING, ROPE MAKING, WIRE ROPES, ETC.)

IT is obvious that although the term tying has a simple, almost homely, meaning, in practice, where perfect security has to be obtained tying is immediately raised to an art. The examples here given represent the best known knots and rope fastenings and the methods of making them, included with which are the well-known "clove hitch," and the rather famous "diamond hitch," the latter being used for securing irregular shaped loads on pack animals.

Tying.—*The Thumb knot, a, and figure of* 8, *b* (Fig. 272), are used to prevent ropes passing through blocks or slipping. To make the figure of 8 knot, pass the end of the rope under, round, and over the standing part, then up through the bight or loop. *The Reef knot, c,* is useful for joining together two ropes of equal size. With dry rope, it is equal in strength to the other part. If wet, the knot will generally slip before the rope breaks.

The standing and running parts of each rope must pass through the loop in the same direction, i.e. from above downwards, or *vice versa.* If they pass in the opposite direction the knot is termed a granny, and cannot be undone when tightened up with the same ease that a reef knot can. *A Draw reef knot, d,* is made in the same manner, except that a bight is drawn through instead of the rope end; it is useful to cast off when in an inaccessible position. *Single sheet bend, e,* is used for joining the ends of a rope, or hanging to a bight. Take a bight or double at one end, holding it in the left hand, and pass the end of the other rope held in the right hand up through this bight, down on one side under and up over the bight, and under its own standing end. *The Double sheet bend, f,* in which the running end is passed twice round the bight and under its own standing end each time, is used where greater security is required; *g* shows *two Half-hitches*; *h, Round turn and two half-hitches*; and *i*, the *Fishermen's bend.* In the latter, two turns are taken round the spar, or other object, and the end is passed over the standing part, and through the turns next to the spar, over its own part then forming one half-hitch, the second half-hitch being taken round the standing part alone. It is very useful for attaching ropes to rings or staples. Sometimes it is necessary to shorten a length of rope quickly. This can be done as shown by *Sheepshank, k*; lay the rope up in 3 parts, and a hitch taken over each bight, with the standing and running parts respectively of the rope, and drawn tight. To secure a rope to the end of a beam or spar, a *Clove hitch, l m n,* is used, made as follows:—Grasp the rope with the left hand, back down, and right hand back up. Reverse each hand so as to form two loops, *l*, lap them together as at *m*, and slip the two loops so formed over the end of beam or spar. In case the loops cannot be slipped on to the end, pass the end over and round the spar, and bring it up to the left of the standing part, and again round the spar, in the same direction, to the right of the first turn, and bring the end up, between the spar, the last turn, and the standing part *n*. This is one of the most useful knots for making fast to an object; it is very simple, and so effective that generally the rope breaks before slipping.

Timber hitch, o, is useful for lifting timber or dragging spars. When properly made, it will not slip; it is easily undone when the strain is taken off. Pass the end round the spar, and round its standing part, close to the spar. Then twist it two or three times back round itself, and draw tight. A half-hitch taken with the standing part adds to its security.

Bowline knot is shown in *p, r, s.* Holding the standing part in the left hand, form a loop in the rope running end uppermost, loop towards the body;

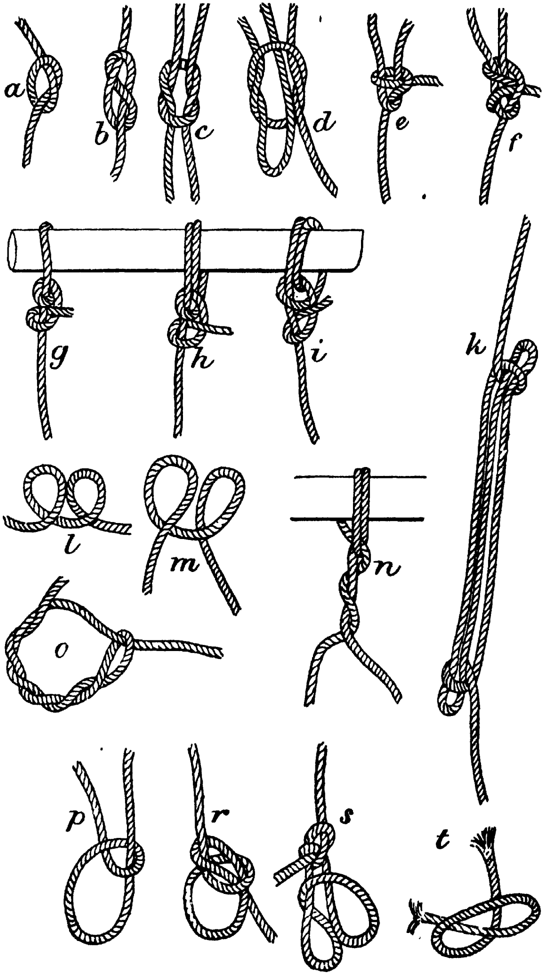


FIG. 272.

pass the running end up through the loop, as shown at *p*, down under the standing part from right to left, back over the standing part, and through the original loop; then draw taut the end and double of the loop together, *r*. A running bowline, *s*, can be formed round a spar, and tightened at any point. To make it, take the coil of the rope in the left hand, pass the running end round the spar from left to right, and draw it back with the right hand as far as required; still holding the end in the right hand; take the standing part in the same hand; pass the left hand under the standing part, and with the finger and thumb seize the running part of the rope close to the spar; draw it underneath the standing part from right to left and up, and at that point make a bowline knot on it with the running end. The knot is then run through the loop. Its use is to form a loop at the end of a rope that will not slip, or tighten up.

Catspaw, *t*: 2 loops made on a rope in order to hang a tackle on. To make it form two equal bights or loops, *t*. Grasp a loop in each hand, and roll them on the standing part 3 or 4 complete turns; then hook into both loops A, Fig. 273. This is an exceedingly handy method of attaching a rope to the block hook, owing to its simplicity, and the ready manner in which it can be eased off.

Whipping, B C D. To whip a rope is to tie a piece of small twine round the end, to prevent the strands from untwining and forming loose ends. Ropes intended for tackles particularly should be whipped before the blocks are threaded. When treated in this manner ropes will easily pass through the block sheaves, thus preventing much annoyance and waste of rope, it being quite a common occurrence with some workmen to cut a yard off the rope end because it is frayed. Take a piece of fine twine, 2–3 ft. long in proportion to the size of the rope, and place it as shown in B, one end to the right, the other to the left, quite close to the rope. Wind the loop *a b c* tightly round the end of the rope *f*, and the two ends *d e* of the whipping twine, a sufficient number of times to secure the ends C; then by drawing the two ends *d e* tight, the whipping is tightened up D.

E represents a *double Blackwall hitch*. It is used for securing a tackle to a rope. To make it, place the rope near its end, against the hook of the block at *a*, cross the rope at *b*, and again inside the hook at *c*. If seized with a few turns of twine at *d* it will be more secure. This method of attachment will in a great measure prevent the rope from cutting itself on the hook.

Carrick bend, F. Lay the end of a rope or chain under its own standing part, as shown at G, then with another rope or chain *c d*, lay its end under both parts of the eye formed by *a b*, and parallel to that part which is uppermost; then bring it alternately over and under the parts of *a b* and itself. This knot is used for fastening the four guys to a derrick. But its principal use is for bending a large rope to a small one.

Drag rope knot, H I K. This is a useful knot for attaching hand spikes to drag by. It may also be used as a ladder by securing it firmly at each end.

The Sheet-bend or Weavers' knot, A, Fig. 274. This knot is usually employed by netters, and is called by sailors "the sheet bend." It is readily made by bending one of the pieces of cord into a loop *a b*, which is to be held between the finger and thumb of the left hand; the other cord *c* is passed through the loop from the farther side, then round behind the two legs of the loop, and lastly under itself, the loose end coming out at *d*. In the smallness of its size, and the firmness with which the various parts grip together, this knot surpasses every other; it can, moreover, be tied readily when one of the pieces *a b* is exceedingly short; in common stout twine, less than 1 in. is sufficient to form the

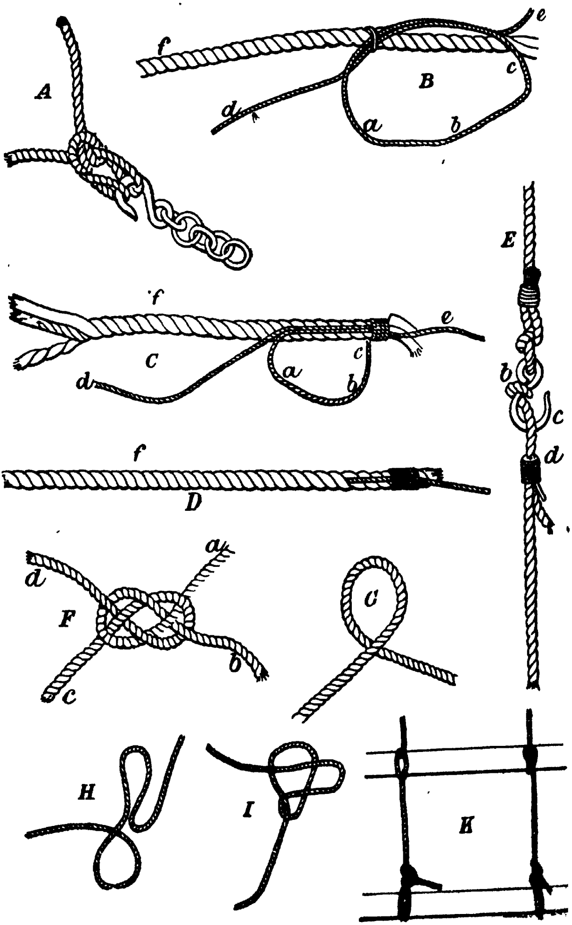


FIG. 273

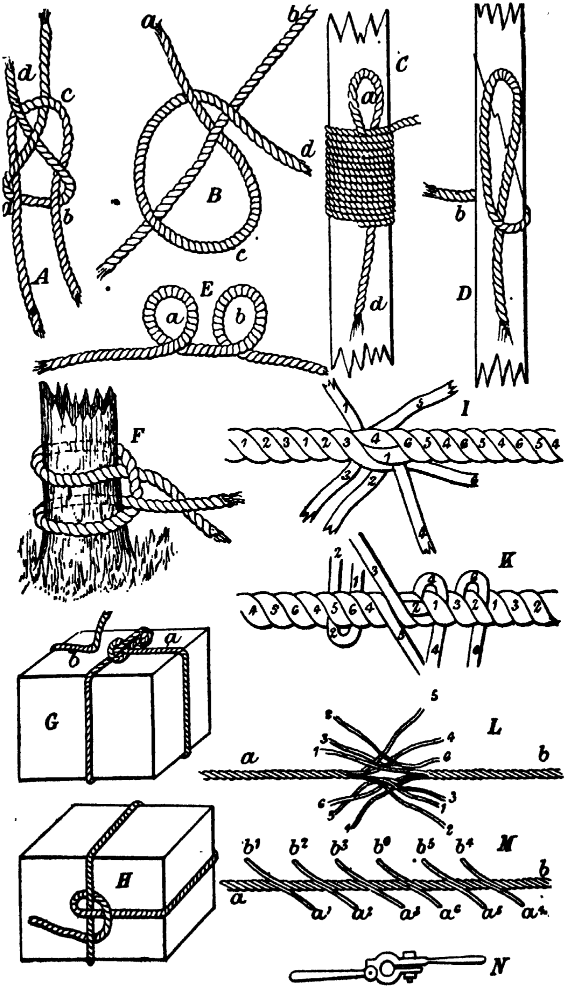

d
c
a
b
A
a
b
d
B
c
C
a
d
b
D
E
a
b
F
I
1 2 3 1 2 3 4 6 5 4 6 5 4 6 5 4
K
4 5 6 4 5 6 4 2 1 3 2 1 3 2
a
b
G
H
L
a
b
1 2 3 4 5 6
M
b¹ b² b³ b⁶ b⁵ b⁴
a
b
a¹ a² a³ a⁶ a⁵ a⁴
N

FIG. 274.

loop. The above method of forming it is the simplest to describe, although not the most rapid in practice; as it may be made in much less time by crossing the two ends of cord *a b* in B on the tip of the forefinger of the left hand, and holding them firmly by the left thumb, which covers the crossing; then the part *c* is to be wound round the thumb in a loop, as shown in the figure, and passed between the two ends, behind *a* and before *b*; the knot is completed by turning the end *b* downwards in front of *d*, passing it through the loop *c*, and tightening the whole by pulling *d*. As formed in this mode, it is more rapidly made than almost any other knot; and, as before stated, it excels all in security and compactness; so firmly do the various turns grip each other that, after having been tightly pulled, it is very difficult to untie; this is the only drawback to its usefulness, and in this respect it is inferior to the reef-knot, which is made in precisely the same manner that a shoe-string is tied, only pulling out the ends instead of leaving them as bows.

Binding knot, C D.—This knot is exceedingly useful in connecting broken sticks, rods, etc., but some difficulty is often experienced in fastening it at the finish; if, however, the string is placed over the part to be united, as shown in D, and the long end *b* is used to bind around the rod, and finally passed through the loop *a*, as shown in C, it is readily secured by pulling *d*, when the loop is drawn in, and fastens the end of the cord.

Clove hitch, E F.—For fastening a cord to any cylindrical object, one of the most useful knots is the clove hitch, which, although exceedingly simple and most easily made, is one of the most puzzling knots to the uninitiated. There are several modes of forming it, the most simple being perhaps as follows:—Make two loops, precisely similar in every respect as *a* and *b* in E, then bring *b* in front of *a*, so as to make both loops correspond, and pass them over the object to be tied, tightening the ends; if this is properly done the knot will not slip although surrounding a tolerably smooth cylindrical object, as a pillar, pole, etc. This knot is employed by surgeons in reducing dislocations of the last joint of the thumb, and by sailors in great part of the standing rigging. The loop which is formed when a cable is passed around a post or tree to secure a vessel near shore, is fastened by what sailors term two half-hitches, which is simply a clove hitch made by the end of the rope which is passed around the post or tree, and then made to describe the clove hitch around that part of itself which is tightly strained, as in F.

The Diamond hitch, Fig. 275. This is largely used for tying goods to be carried on animals' backs. The pack saddles *e* may be of the simplest description, resembling small, light sawbucks, with side boards fastened under the crossed pieces, to come upon the animal's back. In saddling, a piece of blanket is first put on, then the saddle is girthed, or "cinched," on very tightly.

The operation of packing involves the use of the peculiar knot, very famous in its way, termed the "diamond hitch." By its agency the packs are fastened rigidly in position on the back and sides of the animal carrying them. After the animal has been saddled, the packs, divided into two even portions, are slung up, half on each side, by two packers. To the parts of the saddle corresponding to pommel and cantle, short lines are fastened. The packers hold the packs up against each side of the pack animal, and passing the ropes around the articles from underneath, and up, over, and across the back, tie the ends together so as to hold all in position. Any small articles are piled on top, and all is ready for the diamond hitch.

To make this, a piece of 2 or 3 in. rope is used, about 30 ft. long. One end is fastened to a short girth or cinch *d*. To the other end of the cinch is secured a large flat hook, generally made of wood. In the army a long leather strap, about 1 in. wide, is used instead of the rope. Throughout the whole operation the packers work in pairs. One stands on the near or left side of the animal, whom we shall designate as A: the other stands on the off or right side, and will be called B. The packing rope and cinch are taken by A on the near side. He swings the hook end of the cinch across under the animal's belly to B, who catches it. Then A makes a bight in the part of the rope near the cinch, and throws it over across the top of the pack to B, who inserts it in the hook. Thus two leads of the rope run over the top of the pack transversely. A then turns a half-hitch with a large loop in the next succeeding part of the rope, and passes the free end to B. This end B passes over the second and under the first lead of the rope lying across the packs, and as near the centre as may be. The state of things at this point is shown in *a*, Fig. 275.

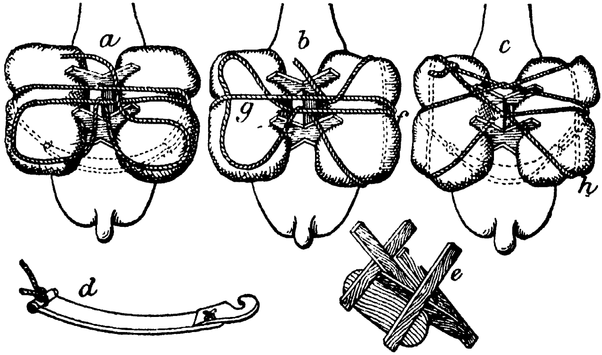


FIG. 275.

The left-hand part of the half-hitch is passed under the cross-rope by A, while the free end of the rope is passed as described by B. *b* shows this phase of the operation. In this way two loops are formed, one for each side. A's loop lies under the cross line, while B's loop comes outside of everything. All these operations are executed in a few seconds, no exact order being followed. The tightening process comes next. B begins to pull the rope backward and upward, grasping it at *f*, putting his knee, or even foot, against the hook for a purchase, while A takes in the slack as fast as given him from B's successive pulls, grasping and pulling the rope at *g*. When no more can be gained, and the poor brute is compressed as much as possible, A passes the loop on his side tightly around and partly underneath his half of the pack. Then B, grasping the rope at *h*, pulls diagonally backward and outward. This begins to "spread the diamond." He next puts his loop in position, when A, taking hold of the free end of the rope, pulls it diagonally forward and outward, over the withers of the horse. This completes the spreading of the diamond, and it will be at once seen that this separation of the two leads of the rope tightens it with enormous power. After A has given the final pull, he ties the free end of the rope wherever convenient, thus completing all. The final result is shown in *c*. The last two pulls consolidating the pack nearly double up the poor animal. The cinch, often cruelly narrow, is drawn up into his belly until the profile forms a double curve, his body being violently squeezed upward. After packing, the poor beast will sometimes go off, as it were, on tiptoes, trying to relieve himself by motion. To untie the hitch, the end of the line is untied and cut loose, and withdrawn from under the cross lead of the rope. Then the whole being slackened, the bight is withdrawn from the hook, and the rope comes off without a knot. If a knot is formed, it is a sign that a mistake has been made in the tying.

The tightness of the "lacing" to which the animals are subjected has an element of mercy in it, because, if the saddle shifts about, a sore back inevitably results.

For roping large, irregular bundles, the diamond hitch is well adapted, and its power in such cases is surprising. A simple loop tied on the end of the rope is made to serve instead of the cinch loop. ('Scient. Amer.')

Tying Fish-hooks.—The majority of hooks used for sea-fishing have flattened heads or ends, not eyes, and the twine snood is tied to them by two half-hitches as Figs. 276 and 277. The first figure shows how the twine has to be twisted by the finger into two loops, with the ends passing as shown. The head of the hook is passed straight through the two loops, which are then drawn tight on it as the second figure shows. The two ends are then twisted together to form the snood, which should be a little over a foot long.

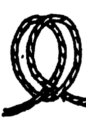


FIG 276.

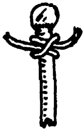


FIG. 277.

Tying Gut to Eyed Fish-hooks.—First pass the end of the gut through the eye of the hook, take the gut round the shank, then return it through the eye (if the eye is large enough, if not pass it under the eye) and lastly tie a simple thumb knot around about the eye as the sketch (Fig. 278) shows. A safer tie can be effected as Fig. 279, the chief difference being the double or repeated knot above the eye. The chief advantage of this is that the end of the gut can be cut off fairly close, whereas with Fig. 278 the end has to be left longer to avoid the possibility of its drawing out. Gut must be put in warm water (or in the mouth) a little time before tying.

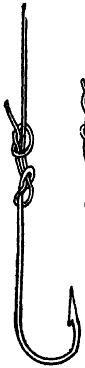


FIG. 278.

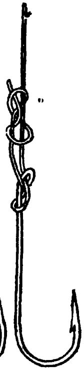


FIG. 279.

Tying a Parcel, GH (Fig. 274).—The tying up of parcels in paper is an operation which is seldom neatly performed by persons whose occupations have not given them great facilities for constant practice. Let a single knot be made in the end of the cord, which is then passed around the box or parcel. This knotted end is now tied by a single hitch around the middle of the cord G, and the whole is pulled tight. The cord itself is then carried at right angles round the end of the parcel, and where it crosses the transverse cord on the bottom of the box H it should, if the parcel is heavy and requires to be firmly secured, be passed over the cross cord, then back underneath it, and pulled tightly, then over itself; lastly, under the cross-cord, and on around the other end of the box. When it reaches the top, it must be secured by passing it under that part of the cord which runs lengthways in *a* G, pulling it very tight, and fastening it by two half-hitches round itself. The great cause of parcels becoming loose is the fact of the cord being often fastened to one of the transverse parts as *b* in G, instead of the piece running lengthways, and in this case it invariably becomes loose. The description may perhaps be rendered clearer by the aid of the figures, which exhibit the top and bottom of a box corded as described. The cords, however, are shown in a loose state, to allow their arrangement to be perceived more easily.

Splicing. *Short splicing*, IK (Fig. 274).—There are two ways of making a short splice—one by passing the strands left-handed, and the other by passing them right-handed. But the former method is the more generally adopted, because of its neat appearance. Unlay the strands of each rope about 1 ft. or more, then crutch them together—that is, lay them so that each strand lies in a groove of the rope. Afterwards pass a strand of one rope over a strand of the other, as shown in I, front view, where No. 4 is passed over No. 1, so as to form a common knot. In a like manner pass No. 5 over No. 3, and No. 6 over No. 2. Draw these strands tight, and proceed as follows:—Take strand No. 6, K, back view, and after reducing the yarns by cutting a few out of the inside, pass it over No. 2; continue doing so until it is worked out. It will be seen, by reference to K, that No. 6 is passed three times over No. 2, but the third time it is merely pushed through and not drawn tight. Strands Nos. 4 and 2 are in a similar position. All the corresponding Nos. represent the same strand, so No. 4 will pass over the same strand (No. 1) till worked out; No. 1 over No. 4, and No. 2 over No. 6. No. 5 which is shown loose, passes over No. 3. In passing the strands be careful to reduce the yarns each time after the first, and spread them out so that they will lie flat, and also see that all the yarns lie parallel.

Splicing Wire Rope, L M N (Fig. 274).—The increasing use of endless wire rope for underground haulage, elevated wire ropeways, and for hoisting, gives importance to methods of splicing.

About 24 ft.* of rope is required to put in a good smooth long splice. The wire ropes employed in ropeways are made of 6 strands of 7 wires each, and a core or heart; as there are two rope ends to splice together, there will consequently be 12 strands to be tucked in. Operators usually tie the stops that mark the length of rope, about where the centre of the splice will be. In this case the usual way is to unlay each rope up to that point, and place the strands of rope *a* between the strands of rope *b*, the cores or hearts of the ropes *a* and *b* being cut off so that the cores of the ropes abut against each other. There will be then 12 ft. of strands each side of the stop (see L, Fig. 274).

It is important that each strand should be in its proper place, so that none of them crosses other strands, or that two strands be not where one strand should be (by placing your fingers between each other in natural position this will be understood). Then strand No. 1 of rope *a* is unlaid, and strand No. 1 of rope *b* follows close, and is laid snugly and tightly without kink or bend in its place, until within 7 ft. of the end; a temporary seizing is then put on, securing ropes and strands at this point. Strand No. 1 of rope *a* is then cut off, leaving it 7 ft. long. Then strand No. 2 of rope

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* The length is controlled by the thickness, about 40 times the circumference is desirable, thus with a 2-in. rope, 2 × 3 × 40 = 240 in. or 20 ft.

a is unlaid, and strand 2 of rope *b* is laid in its place to within 21 ft. of its end. Strand No. 3 of rope *a* is unlaid, and strand No. 3 of rope *b* is laid in its place to within 35 ft. of end. By this time you have reached within 7 ft. of the centre, and, reversing the operation, unlay strand No. 4 of rope *b*, and lay in its place strand No. 4 of rope *a*, to within 7 ft. of its end; unlay No. 5 of rope *b*, and lay in No. 5 of rope *a*, to within 21 ft. of its end; finally, unlay No. 6 of rope *b*, and lay in its place No. 6 of rope *a*, to within 35 ft. of its end. The strands are now all laid in their places and seized down for the time being, the ends are cut off, as with the first strand, to 7 ft. long, and present the appearance as in M.

The next operation is to tuck in the ends, and we will proceed to tuck in *b* 1. It will be remembered that the ropes are made of 6 strands, laid around a core or heart, usually of hemp, of the same size. Two clamps N made for this purpose are fastened on the rope so as to enable the operator to untwist the rope sufficiently to open the strands and permit the core to be taken out, which is cut away, leaving a space in the centre of the rope; the strand *b* 1 is placed across *a* 1, and put in the centre of the rope in place of the extracted core, forming, in fact, a new core. A flat-nosed T-shaped needle used in splicing, the point of which is about ½ in. wide by $\frac{3}{16}$ in. thick, rounded off to an edge, is well adapted to this purpose. The strand *b* 1 is laid in its entire length, the core being cut off exactly at the extremity of strand *b* 1, so that when the rope is enclosed around the inserted strand, the ends of the strand and core should abut. If there is much space left in the centre of the rope without a core, the rope is liable to lose its proper form, and some of the strands fall in, exposing the projecting strands to undue wear. The same operation is performed with *a* 1, running the other way of the rope, and so on, until all the strands are tucked in, which, if properly done, will leave the rope as true and round and as strong as any other part.

Some operators prefer to start from the end of one rope and consequent end of splice. The operation is about the same, but more care has to be used in bringing all the strands to an even tension in the parts spliced.

The long splice just described ensures uniform diameter and no reduction in strength. Hemp and wire ropes are spliced in the same way, but with wire the splice has always to be of the greater length owing to the less friction and holding power between the strands. A short splice is not so strong and makes a bulge where it occurs. A short splice in wire rope can be made commencing as Fig. 280. Here the strands, after being opened out for about 9 in. to 12 in. (according to the size of the rope), are placed together in alternate positions, this being called "marrying" the ends. The operation is then to pass each strand over and under the next strands, some three to six times in succession. The strands are interlaced once before the rope is pulled taut, after which the interlacing is done by opening between the strands with a metal marlinspike, using grease if necessary. When the interlacing is

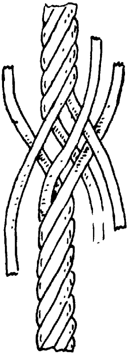

FIG. 280.

completed, pull the rope as taut as possible, then roll the splice between boards to reduce its diameter as much as possible. It is not easy work for an amateur, and requires considerable care and practice. Before cutting or finally tucking in the ends, the rope should be stretched on a winch, a mallet and block being used freely.

When a splice has to be made that must pass through a pulley block, assuming the rope has six strands, unwind three alternate strands on each end and cut all other strands off. Put the cut ends together and work in the loose strands in opposite rope, under one strand, over the next and back again until reaching the end of the strand, which is pointed and beaten home into the body of the rope.

(For details of tools and methods used in splicing kilindo rope *see* WIRE ROPES).

* * *

VALVE-GRINDING.

THE throttles upon all steam machines generally require grinding at regular intervals, and a few words as to the proper method of performing this apparently simple operation may not be out of place. The writer has been in repair shops and seen supposedly competent men grinding poppet-valves, whether for steam throttle or for gasoline inlet or exhaust, holding one part in a chuck in the lathe and the other part in the hand, and running the lathe at a rapid rate, feeding the grinding material around the joint to be ground and bringing pressure upon the parts by the hand. This is decidedly the wrong way to accomplish the desired end—viz. a perfectly straight, true surface at the valve seat entirely free from rings.

These rings or grooves once started upon the seat and valve-surface of any form of poppet-valve, it is almost impossible to efface them by subsequent grinding, no matter however carefully done, and the only remedy would consist in machining the surfaces down to true again, putting the valve into the lathe and turning up a new surface and using a special angular milling cutter or reamer for the seat. If a due amount of care is exercised in the grinding, these expedients will never become necessary; and in grinding such valves the surfaces should be smeared with machine-oil and emery, using about No. 90 to begin with for most work, and finishing with flour of emery. The greatest care should be taken that none of the emery fall upon other working surfaces, and that none remains in the valve-chamber after the operation.

In the case of a steam throttle, one piece should be held in a vice and the other part turned by the fingers or a screwdriver, with the application of only moderate pressure, as too heavy pressure will be apt to produce the grooves above referred to. The parts should be turned first in one direction, then in the other, turning in one direction a little farther than in the other each time, so that the valve is continually revolving over all portions of the seat. As soon as the grinding material has ceased to cut—which can be felt and heard—the old material should be wiped off and replaced by fresh. In the case of a steam throttle, where both surfaces are of brass, it is a good plan to finish with grindstone grit. The ground surfaces should not be shiny when finished, but should have a dull, frosty appearance, and both valve and seat should show a uniform character of surface all the way round. ('The Horseless Age.')

VARNISHES AND VARNISHING.

(*See also* JAPANNING, LACQUERS AND LACQUERING, PAINTING, POLISHES AND POLISHING, WATERPROOFING, ETC.)

Properties.—Varnish is a solution of a resinous substance in oil, turpentine or alcohol. The oil dries and the other two solvents evaporate, in either case leaving a solid transparent film of resin over the surface varnished. In estimating the quality of a varnish the following points must be considered: (1) Quickness in drying; (2) hardness of film or coating; (3) toughness of film; (4) amount of gloss; (5) permanence of gloss of film; (6) durability on exposure to weather. The quality of a varnish depends almost entirely upon that of its ingredients; much skill is, however, required in mixing and boiling the ingredients together. Varnish is used to give brilliancy to painted surfaces, and to protect them from the action of the atmosphere or from slight friction. It is often applied to plain unpainted wood surfaces in the roofs, joinery and fittings of houses, and to intensify and brighten the ornamental appearance of the grain. Also to painted and papered walls. In the former case it is sometimes "flatted" so as to give a dead appearance, similar to that of a flatted coat of paint.

Materials—Gums are exudations from trees. At first they are generally mixed with some essential oil; they are then soft and viscous, and are known as balsams; the oil evaporates and leaves the resin, which is solid and brittle. Resins are often called "gums" in practice, but a gum, properly speaking, is soluble in water, and therefore unfit for varnishes, while resins dissolve only in spirits or oil. Gum-resins are natural mixtures of gum with resin, and sometimes with essential oil, found in the milky juices of plants. When rubbed up with water, the gum is dissolved, and the oil and the resin remain suspended.

The quality of the resin greatly influences that of the varnish. The softer varieties dissolve more readily than others, but are not so hard, tough or durable. *Common rosin or colophony* is either brown or white; the brown variety is obtained by distilling the turpentine of spruce fir in water; the white is distilled from Bordeaux turpentine. The principal resins used in good work are as follows:—

Amber, obtained chiefly from Prussia, is a light yellow transparent substance found between beds of wood coal, or after storms on the coast of the Baltic; is the hardest and most durable of the gums, keeps its colour well, and is tough, but difficult to dissolve, costly, and slow in drying. *Gum animi* is imported from the East Indies; is nearly as insoluble, hard and durable as amber, but not so tough; makes a varnish quick in drying, but apt to crack, and the colour deepens by exposure. *Copal* is imported from the East and West Indies and America, etc., in three qualities, according to colour, the palest being kept for the highest class of varnish; these become light by exposure. *Mastic* is a resinous gum from the Mediterranean; it is soft, and works easily. *Gum dammar* is extracted from the Kauri pine of New Zealand, and comes also from India; makes a softer varnish than mastic, and the tint is nearly colourless. *Gum elemi* comes from the West Indies and somewhat resembles copal. *Lac* is a resinous substance which exudes from several trees found in the East Indies; more soluble than the gums above mentioned; stick lac consists of the twigs covered with the gum; seed lac is the insoluble portion left after pounding and digesting stick lac; when seed lac is melted, strained and compressed into sheets, it becomes shell lac; of these three varieties shell lac is the softest, palest and purest, and it is therefore used for making lacquers. *Sandarach* is a substance said to exude from the juniper tree; resembles lac, but is softer, less brilliant and lighter in colour, and is used for pale varnish. *Dragon's blood* is a resinous substance imported from various places in dark brown-red lumps, in bright red powder, and in other forms; used chiefly for colouring varnishes and lacquers.

Solvents must be suited to the description of gum they are to dissolve. Boiling linseed-oil (and sometimes other oils, such as rosemary) is used to dissolve amber, gum animi or copal. Turpentine for mastic, dammar and common resin. Methylated spirits of wine for lac and sandarach. Wood naphtha is frequently used for cheap varnishes; it dissolves the resin more readily than ordinary spirits of wine, but the varnish is less brilliant, and the smell of the naphtha is very offensive, therefore it is never employed for the best work.

Driers are generally added to varnish in the form of litharge, sugar of lead, or white copperas. Sugar of lead not only hardens but combines with the varnish. A large proportion of driers injures the durability of the varnish, though it causes it to dry more quickly.

LINSEED OIL.—The choice of linseed oil is of peculiar consequence to the varnish maker, as upon its quality, to a great extent, depend the beauty and durability of the varnish. Oil expressed from green unripe seeds always abounds with watery, acidulous particles. The quality of oil may be determined in the following manner. Fill a phial with oil, and hold it up to the light; if bad, it will appear opaque, turbid, and thick; its taste is acid and bitter upon the tongue, and it smells rancid and strong: this ought to be rejected. Oil from fine full-grown ripe seed, when viewed in a phial, will appear limpid, pale, and brilliant; it is mellow and sweet to the taste, has very little smell, is specifically lighter than impure oil, and when boiled or clarified dries quickly and firmly, and does not materially change the colour of the varnish when made, but appears limpid and brilliant.

Boiling Linseed Oil.—Procure a copper pan, Fig. 281, made like a common washing copper, set it upon the boiling furnace, and fill up with linseed oil within 5 in. of the brim. Kindle a fire in the furnace underneath, and manage the fire so that the oil shall gradually but slowly increase in heat for the first two hours; then increase the heat to a gentle simmer, and if there is any scum on the surface, skim it off with a copper ladle, and put the skimmings away. Let the oil boil gently for three hours longer, then introduce, by a little at a time, a quarter of an ounce of the best calcined magnesia for every gallon of oil, occasionally stirring the oil from the bottom. When the magnesia is all in, let the oil boil rather smartly for one hour; it will then be sufficient. Lay a cover over the oil to keep out the dust while the fire is drawn and extinguished by water; then uncover the oil, and leave it till next morning; and then, while it is yet hot, ladle it into the carrying jack, or let it out through the pipe and cock; carry it away, and deposit it in either a tin or leaden cistern, for wood vessels will not hold it; let it remain to settle for at least three months. The magnesia will absorb all the acid and mucilage from the oil, and fall to the bottom of the cistern, leaving the oil clear, transparent, and fit for use. Recollect, when the oil is taken out, not to disturb the bottoms, which are only fit for black paint.

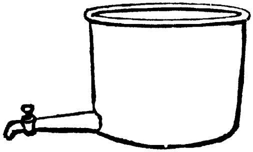

FIG. 281.

SPIRITS OF TURPENTINE. — That which is used for mixing varnish ought to be procured and chosen as pure, strong and free from acid as possible. Some turpentine being drawn from green trees abounds with a pyroligneous acid, which rises and comes over with the spirit in distillation; it is strong and bitter to the taste, and appears milky, particularly towards the bottom, after standing to settle. Therefore, the longer turpentine is kept before it is used, the purer it will be.

CHOOSING GUMS AND SPIRITS.—In purchasing gum, examine it, and see that it consists, for the most part, of clear transparent lumps, without a mixture of dirt; select the clearest and lightest pieces for the most particular kinds of varnish, reserving the others, when separated from extraneous matter, for the coarser varnishes. In choosing spirits of wine, the most simple test is to pour a small quantity into a cup, set it on fire, and dip a finger into the blazing liquid; if it burns quickly out, without burning the finger, it is good; but if it is long in burning, and leaves any dampness remaining on the finger, it is mixed with inferior spirit; it may be also compared with other spirit, by comparing the weight of equal quantities, the lightest is the best. The goodness of spirits of turpentine may be likewise ascertained by weighing it, and by noticing the degree of inflammability it possesses; the most inflammable is the best; and a person much in the habit of using it will tell by the smell its good or bad qualities; for good turpentine has a pungent smell, the bad a very disagreeable one, and not so powerful.

Kinds of Varnish.—Varnishes are classified as oil varnish, turpentine varnish, spirit varnish, or water varnish, according to the solvent used. They are generally called by the name of the gum dissolved in them.

Oil varnishes, made from the hardest gums (amber, gum animi, and copal) dissolved in oil, require some time to dry, but are the hardest and most durable of all varnishes; are specially adapted for work exposed to the weather, and for such as requires polishing or frequent cleaning; are used for coaches, japan work, for the best joinery and fittings of houses, and for all outside work. *Turpentine varnishes* are also made from soft gums (mastic, dammar, common rosin) dissolved in the best turpentine; are cheaper, more flexible, dry more quickly, and are lighter in colour than oil varnishes, but are not so tough or durable. *Spirit varnishes* or lacquers are made with softer gums (lac and sandarach) dissolved in spirits of wine or pyroligneous spirit; dry more quickly, and become harder and more brilliant than turpentine varnishes, but are apt to crack and scale off, and are used for cabinet and other work not exposed to the weather. Water varnishes consist of lac dissolved in hot water, mixed with just so much ammonia, borax, potash, or soda, as will dissolve the lac; the solution makes a varnish which will just bear washing; the alkalies darken the colour of the lac.

In preparing oil varnishes the gum must first be melted alone till it is quite fluid, and then the clarified oil is poured in very slowly. The mixture must be kept over a strong fire until a drop pinched between the finger and thumb, will, on separating them, draw out into filaments. The pot is then put upon a bed of hot ashes and left for 15 or 20 minutes, after which the turpentine is poured in, being carefully stirred near the surface. The mixture is finally strained into jars and left to settle. Copal varnishes should be made at least 3 months before use; the longer they are kept the better they become. When it is necessary to use the varnishes before they are of sufficient age, they should be left thicker than usual. The more thoroughly the gum is fused, the stronger the varnish and the greater the quantity. The longer and more regular the boiling, the more fluid the varnish. If brought to the stringy state too quickly, more turpentine will be required, which makes the varnish less durable.

Spirit and Turpentine Varnishes.—Here the operation simply consists in stirring or otherwise agitating the resins and solvent together. The agitation must be continued till the resin is all dissolved, or it will agglutinate into lumps. Heat is not necessary, but is sometimes used to hasten the solution of the resin. The varnish is allowed to settle, and is then strained through muslin. In many cases the resin, such as mastic, dammar or common resin, is simply mixed with turpentine alone, cold or with slight heat. Care must in such cases be taken to exclude all oil.

Spirit varnishes give the most brilliant and hard coats, but are not so elastic as OIL VARNISHES, and are not durable for outside work or surfaces liable to damp or heat. With an oil varnish the oil forms a part of the dried coat with the resin or gum, while the turpentine, which first acts as a solvent and gives fluidity, is a volatile material that dries out.

In choosing resins see that they are a light colour, also see that they will fuse at a temperature that will not darken their colour. The oil, too, must be as light as possible and have good drying qualities. No varnish, however well made, has a long life if it is exposed. Using the best gum copal, it may be considered that 18 months is as long as it will last for outdoor or exposed work. With poor resins or gums 6 months may be as long as the varnish will last under trying conditions. The turpentine must be of the best quality, but the American make, though usually specified, is not essential.

Manufacturing Processes.—The processes adopted in making are usually as follows: A copper boiler is used of a capacity 16 times as great as the resin that will be used. The resin is melted about 2 lb. at the time; not more or it may discolour.

When it is nearly fluid, as can be judged by puffs of steam rising, it is stirred with an iron stirrer, and when it will run off the stirrer in drops it is fluid enough. To make sure that all water (steam) is out, let it boil a minute or two. While this has been taking place the oil should have been brought to the boil. The two are then mixed, the oil being poured on to the resin, still heating and stirring to thoroughly incorporate the two. Keep up the heat until a drop of the mixture dropped on to glass gives a strong film of clear varnish. Care must be taken, however, that the heat does not fire the mixture. Before the heating is finished, the varnish should be capable of being drawn into tough threads. The more oil there is the longer the heating must be maintained. The last thing is to add the turpentine. The mixture must first be cooled down considerably and must be away from the fire (or the fire extinguished). Warm the turps and add about an eighth part slowly. Then add still less quantities as slowly as possible. Only experience will tell exactly the best temperature at which to mix in the turpentine. If too low the mixing is not perfect, while if too high some of the turps is lost by evaporation. As the turps is added test the mixture. Put a little to cool on glass, and if it thickens rapidly more turps can be added. The last operation is to filter the varnish through fine net or loosely woven cotton, and then it should be put to settle in a partially darkened warm room for two or three weeks. To thin varnish that is too thick, take a little of the varnish and add turpentine to this and thoroughly well mix; this is then added to the body of the varnish. Should varnish be too thin, a little heat will quickly drive off the excess of turpentine.

MAKING VARNISH ON A SMALL SCALE.—First procure a gum-pot, Fig. 281, or smaller, if required; then a three-footed iron trevet with a circular top, the feet 16 in. in length, and made to stand wider at the bottom than at the top, which is to be made so that the pot will easily fit into it. Place the trevet in a hollow in a yard, garden, or outhouse, where there can be no danger from fire; raise a temporary fire-place round the trevet with loose bricks, after the same manner that plumbers make their furnaces; then make up a good fire with either coke, coal, or wood-charcoal, which is far preferable; let the fire burn to a good strong heat, set on the gum-pot with 3 lb. gum copal; observe, that if the fire surround the gum pot any higher inside than the gum, it is in great danger of taking fire. As soon as the gum begins to fuse and steam, stir it with the copper stirrer, and keep cutting and stirring the gum to assist its fusion; if it feels lumpy and not fluid, and rises to the middle of the pot, lift it from the fire and set it on the ash-bed, and keep stirring until it goes down (meantime let the fire be kept briskly up); then set on the gum pot again, and keep stirring until the gum appears fluid like oil, which is to be known by lifting up the stirrer so far as to see the blade. Observe, that if the gum does not appear quite fluid as oil, carry it out whenever it rises to the middle of the pot, and stir it down again, keeping up a brisk fire; put on the pot, and keep stirring until the gum rises above the blade of the stirrer. Then the copper pouring jack is charged with boiled oil, and held over the edge of the gum-pot; when the gum rises within 5 in. of the pot-mouth, the assistant is to pour in the oil very slowly until towards the last, the maker stirring during the pouring. If the fire at this time is strong and regular, in about eight or ten minutes the gum and oil will concentrate and become quite clear; this is to be tested by taking a piece of glass and dropping a portion of the varnish on it; if it appears clear and transparent, the oil and gum are become concentrated or joined together. It is now to be further boiled until it will string between the finger and thumb; this is known by once every minute dropping a portion on the glass, and taking a little between the forefinger and thumb; pinch it first, then extend wide the finger and thumb; if it is boiled enough, it will stick strong and string out into fine filaments, like birdlime; but when not boiled enough it is soft, thick and greasy, without being stringy. It is a safe plan to have ready a thick piece of carpet large enough to cover the mouth of the boiling pot should it catch fire during the pouring. The moment it is boiled enough, carry it from the fire to the ash-bed, where let it remain from fifteen to twenty minutes, or until it is cold enough to be mixed; have at hand a sufficient quantity of oil of turpentine to fill the pouring pot, begin and pour out with a small stream, gradually increasing, and if the varnish rises rapidly in the pot, keep stirring it constantly at the surface with the stirrer to break the bubbles, taking care not to let the stirrer touch the bottom of the pot, for if it should, the oil of turpentine would be in part converted into vapour, and the varnish would run over the pot in a moment; therefore, during the mixing, keep constantly stirring as well as pouring in at the same time. Have also a copper ladle at hand, and if it should so far rise as to be unmanageable, let the assistant take the ladle and cool it down with it, lifting up one ladleful after another, and letting it fall into the pot. As soon as the varnish is mixed, put the varnish sieve in the copper funnel placed in the carrying tin, and strain the varnish immediately; empty it into open-mouthed jars, tins, or cisterns; there let it remain to settle, and the longer it remains the better it will become. Recollect, when it is taken out, not to disturb or raise up the bottoms.

Plant for Manufacture.—*The building* in which varnish is made ought to be quite detached from any other building whatever, and have a door-way in the centre with folding doors made to lift off the hinges. Let the roof of the building slope to the front; fix also in each end wall a frame and door made to lift off the hinges, so that, when necessary, there may be a free draught through the premises. Let three skylights be made and fixed in the roof, not directly over the furnaces, but on one side, so as to throw light on the furnaces. The skylights and flaps must be well secured by lead flushings, to prevent wet getting in, which might be attended with serious consequences. In the left-hand corner against the back wall, dig out a foundation and fix over a furnace the *set pot*, used for boiling oil, gold size, japan, and Brunswick black. Dig out a foundation facing the front door against the back wall for the boiling furnace, Fig. 282; against the back wall, in the right-hand corner, dig out a foundation for the gum furnace, Figs. 284 and 285; this and all the other furnaces require to have slow fires

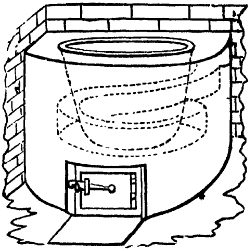

FIG. 282.

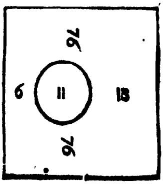

FIG. 283.

kept in them for a day, in order to dry them slowly, and prevent their cracking. Fig. 283, the top plate, is of cast iron.

Gum pot. Procure a copper gum pot to fit into the last furnace, Fig. 284. The bottom *a*, Fig. 284, is hammered out of a solid block of copper, and fashioned, all of one piece, exactly like a hat without the brim. The upper part of the pot *b*, is made of sheet copper, of a cylindrical form, 10 inches diameter at the top, and 2 feet 2 inches high, about ⅜ inch thick; the lower part of the cylinder is then riveted to the bottom with copper rivets, the heads of which are inside, and project through the lappings of the copper, flattened on both sides. Previous to riveting on the bottom, a flange of copper, of about ⅜ inch in thickness, is fixed on to the bottom part, under the large rivets: it is fixed horizontally round the pot. Also previous to riveting on the bottom, put on the iron hoop *d*, 1¼ inches in breadth, to which is welded an iron handle, made 1 inch broad by 1 inch thick, gradually increasing to 2 inches in breadth but decreasing in thickness. The length from pot to handle end, 2 feet 8 inches.

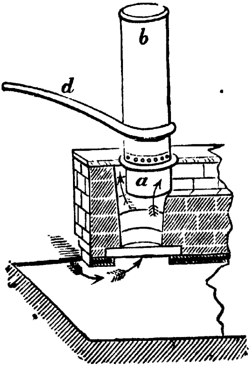

FIG. 284.

Boiling Pot.— Procure a copper pot *c* to fit furnace, Fig. 285, the bottom to be beaten out of the solid, as the gum pot, and of the following dimensions: Diameter across the bottom outside, 20 in.; height of bottom, 7 in.; the cylindrical or body part of the pot, to be 2 ft. 10 in. in depth, and joined to the bottom part with strong copper rivets, made to project through at least three-quarters of an inch, and to be well hammered inside and out; for, as there is no flange, the rivets must be large and strong to support the weight of the pot and its contents while boiling on the furnace plate. It ought to fit the plate neatly, yet so easy as to lift off freely. Seven inches below the mouth of the pot fix on two strong iron handles, one on each side, riveted through each end with two strong rivets; the space for the hands to be 7 in., and 1½ in. in diameter, and to project 4 in. from the pot sides.

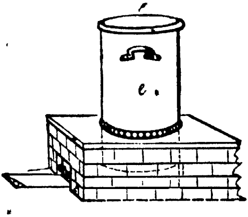

FIG 285.

Small Tools.—In addition to the furnaces the varnish manufacturer requires two copper ladles, made to hold two quarts each, with turned hardwood handles. Two good ladles for the iron set pot, made of sheet copper or sheet iron, with ash handles. For a pot of 40 gal., or upwards, the ladle to hold 3 qt. Two copper stirrers, Fig. 286, made from three-quarter diameter copper rods 3½ ft. long, beaten flat at the one end to 1½ in. breadth, 8 in. up the rod; to be finished with ferruled handles 7 in. in length. One large, strong, copper funnel, with lapped seams, for straining boiling varnish or oil; tin or soldered funnels would melt. One copper oil-jack, Fig. 287, which will contain 2 gal., for pouring in hot or boiling oil, with a large strong pitcher handle, and spout in front. One brass or copper sieve containing 60 meshes to the inch, 9 in. diameter, for straining the first varnish. A brass sieve, 40 meshes to the inch, 9 in. diameter, for straining gold size, turpentine, varnish, boiled oil, etc. A brass sieve, 40 meshes to the inch, and 9 in. diameter, for straining japan and Brunswick black. A saddle, Fig. 288, which is a sheet of plate-iron or tin, 12 in. broad, and turned up 1¼ in. at each side; it is to lie from the edge of No. 1 pot on the edge of the funnel, to prevent the spilling of the varnish during the time of taking it out. A tin pouring pot, to hold 3 gal., made exactly like a garden water pot, only smaller at the spout, and without any rose; this is never to be used for any purpose except pouring oil of turpentine into the varnish. A 3-gal. tin jack made with a strong handle at back and a large broad spout in front; used for receiving the washings when poured out from the gum-pot. A small broom, termed a swish, made from the waste cuttings of cane tied on a small handle, like a hearth broom, for washing out the gum-pot each time it is used; to be always kept clean, and left in oil of turpentine. An iron trevet, made with a circular top 14 in. diameter, with four small cross-bars; the three feet of the trevet 12 in. high; it is used for setting the gum-pot upon, with its bottom upwards, for a minute between each running.

FIG. 286.

FIG 287.

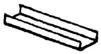

FIG. 288.

Application.—In using varnish, great care should be taken to have everything quite clean, the cans should be kept corked, the brushes free from oil or dirt, and the work protected from dust or smoke. Varnish should be uniformly applied, in very thin coats, sparingly at the angles. Good varnish should dry so quickly as to be free from stickiness in 1 or 2 days. Its drying will be greatly facilitated by the influence of light; but all draughts of cold air and damp must be avoided. No second or subsequent coat of varnish should be applied till the last is permanently hard, otherwise the drying of the under coats will be stopped. The time required for this depends not only upon the kind of varnish, but also upon the state of the atmosphere. Under ordinary circumstances, spirit varnishes require 2–3 hours after every coat; turpentine varnishes require 6 or 8 hours; and oil varnishes still longer, sometimes as much as 24 hours. Oil varnishes are easier to apply than spirit varnishes, in consequence of their not drying so quickly. Porous surfaces should be sized before the varnish is applied, to prevent it from being wasted by sinking into the pores of the material. Varnish applied to painted work is likely to crack if the oil in the paint is not good; also, if there is much oil of any kind, the varnish hardens more quickly than the paint, and forms a rigid skin over it, which cracks when the paint contracts. The more oil a varnish contains the less likely it is to crack. All varnishes improve by being kept in a dry place. One pint of varnish will cover about 16 square yards with a single coat.

To Varnish Furniture.—First make the work quite clean; then fill up all knots or blemishes with cement of the same colour; see that the brush is clean, and free from loose hairs; then dip the brush in the varnish, stroke it along the wire raised across the top of the varnish pot, and give the work a thin and regular coat; soon after that another, and another, always taking care not to pass the brush twice in the same place; let it stand to dry in a moderately warm place, that the varnish may not chill. When the work has had about six or seven coats, let it get quite hard (which prove by pressing the knuckles on it—if it leaves a mark it is not hard enough); then with the first three fingers of the hand rub the varnish till it chafes, and proceed over that part of the work intended to be polished, in order to take out all the streaks or partial lumps made by the brush; then give it another coat, and let it stand a day or two to harden.

PAPER OR CARDBOARD. — In all cases the surface must first be sized with isinglass or gelatine size to prevent the varnish soaking in. This process is as follows. (1) Dissolve 1 oz. of the best isinglass in about a pint of water, by simmering it over the fire; strain it through fine muslin, and keep it for use. Try the size on a piece of paper moderately warm; if it glistens it is too thick, add more water; if it soaks into the paper it is too thin, add or diminish the isinglass till it merely dulls the surface; then give the paper two or three coats, letting it dry between each, being careful (particularly in the first coat) to bear very lightly on the brush, which should be a flat tin camel hair. The size should flow freely from the brush, otherwise the paper, if a drawing, may be damaged. Then take the best mastic varnish, and with it give at least three coats. (2) Boil clear parchment cuttings in water in a clean glazed pipkin till they produce a very clear size, strain it and keep it for use. Give any work two coats of the above size, passing quickly over the work not to disturb the colours; varnish with a paper varnish.

PRINTS, ENGRAVINGS, OR MAPS.— A piece of plate glass is heated, and, while yet warm, a little wax rubbed over it; water is then poured over the plate, and the moistened picture laid thereon and pressed closely down by means of a piece of filtering paper. When dry, the picture is removed, and will be found to possess a surface of great brilliancy, which is not injured by the process of mounting.

Varnish Brushes.—All varnish brushes ought to be made of long white hairs of the best quality, and, for the general purposes of varnishing, have a good regular spring with about one-fourth or fifth part worn off, flat, sharp, and thin at the point, so as to lay on the varnish smoothly and regularly. As the beauty of varnishing depends in a great measure on the brush as well as the manner of laying it on, great care is also necessary that no *oil brush* be put into varnish; therefore, all brushes worn down in oil colour, and intended to be put into varnish, ought previously to be well washed in turpentine, squeezed and dried with a clean linen rag, or well washed with soap and hot water, rinsed in clean warm water, and made perfectly dry. The best method of keeping oil-varnish brushes when not in use is to bore a hole through the handle and put a wire skewer through it, and so suspend the brush in a narrow tin pot containing varnish of the same sort as it was last in, taking care that the varnish in the pot covers the hairs of the brush up to the binding and no higher. Brushes so kept are always straight, clean, pliable, and in good order; whereas varnish brushes kept in turpentine become hard and harsh, and however well stroked or rubbed out, there will still remain turpentine enough to work out by degrees, and spoil the varnishing, by causing it to run streaky or cloudy.

Miscellaneous Receipts. — COPAL VARNISH (*Spirit*). — 1. Melt in an iron pan at a slow heat, copal gum, powdered, 8 parts, and add balsam capivi, previously warmed, 2 parts. Then remove from the fire, and add spirits of turpentine, also warmed beforehand, 10 parts, to give the necessary consistence. Gum copal is made more soluble in spirits of turpentine by melting the powdered crude gum, and allowing it to stand for some time loosely covered.

2. Pounded copal, 24 parts; spirits of turpentine, 40; camphor, 1.

3. Copal in powder, 16 parts; camphor, 2; oil of lavender, 90. Dissolve the camphor in the oil, heat the latter, and stir in the copal in successive portions until complete solution takes place. Thin with sufficient turpentine to make it of proper consistence.

4. Coarsely-powdered copal and glass, of each 4 oz.; alcohol of 90 per cent., 1 pint; camphor, ½ oz.; heat it in a water bath so that the bubbles may be counted as they rise, observing frequently to stir the mixture; when cold decant the clear. Used for pictures.

5. Copal melted and dropped into water, 3 oz.; gum sandarach, 6 oz.; mastic and Chio turpentine, of each, 2½ oz.; powdered glass, 4 oz.; alcohol of 85 per cent., 1 qt.; dissolve by a gentle heat. Used for metal, chairs, etc.

White Copal Varnish.—4 oz. copal, ½ oz. camphor, 3 oz. white drying oil, 2 oz. essential oil of turpentine. Reduce the copal to powder, mix the camphor and drying oil, then heat it on a slow fire, and add the oil of turpentine, and strain.

Copal Varnishes for Fine Paintings.—Fuse 8 lb. of very clean pale African gum copal, and when completely fluid, pour in 2 gal. of hot oil; let it boil until it will string very strong; and in about fifteen minutes, or while it is yet very hot, pour in 3 gal. of turpentine. Perhaps, during the mixing, a considerable quantity of the turpentine will escape, but the varnish will be so much the brighter, transparent, and fluid; and will work freer, dry quickly, and be very solid and durable when dry. After the varnish has been strained, if it is found too thick, before it is quite cold, heat as much turpentine and mix with it as will bring it to a proper consistence.

Artists' Virgin Copal.—From a select parcel of scraped African gum copal, pick out the fine transparent pieces which appear round and pale like drops of crystal; break these small; dry them in the sun, or by a very gentle fire. Afterwards, when cool, bruise or pound them into a coarse powder; then procure some broken bottles or flint glass, and boil the same in soft water and soda, then bruise it into coarse powder like the gum; boil it a second time, and strain the water from it, washing it with three or four waters, that it may be perfectly clean and free from grease or any impurity; dry it before the fire, or upon a plate; set it in an oven. When it is thoroughly dry, mix 2 lb. of it with 3 lb. of the powdered copal; after mixing them well, put them into the gum-pot and fuse the gum; keep stirring all the time; the glass will prevent the gum from adhering together, so that a very moderate fire will cause the gum to fuse. When it appears sufficiently run, have ready 3 qt. of clarified oil, very hot, to pour in. Afterwards let it boil until it strings freely between the fingers; begin and mix it rather hotter than if it were body-varnish; pour in 5 qt. of old turpentine, strain it immediately, and pour it into an open jar or large glass bottle; expose it to the air and light, but keep it both from the sun and wet, and from moisture, until it is of a sufficient age for use. This is the finest copal varnish for fine paintings or pictures.

Quick Drying Body Copal Varnish. 8 lb. of the best African copal, 2 gallons of clarified oil, ¼ lb. of dried sugar of lead, 3½ gallons of turpentine; boiled till stringy, and mixed and strained; 8 lb. of fine gum anime, 2 gallons of clarified oil, ¼ lb. of white copperas, 3½ gallons of turpentine; boiled as before; to be mixed, and strained while hot, into the other pot. These two pots mixed together will dry in six hours in winter, and in four in summer; it is very useful for varnishing old work on dark colours.

Best Body Copal Varnish for Coach Makers.—Fuse 8 lb. of fine African gum copal; add 2 gal. of clarified oil; boil very slowly for four or five hours, until quite stringy; mix off with 3½ gal. of turpentine; strain off, and pour it into a cistern.

CABINET VARNISH.—Fuse 7 lb. of fine African gum copal, and pour in half a gal. of clarified oil; in three or four minutes after, if it feels stringy, take it out of doors, and mix with it 3 gal. of turpentine; afterwards strain it, and put it aside for use. This, if properly boiled, will dry in ten minutes, but if too strongly boiled will not mix at all with the turpentine; and, *sometimes*, when boiled with the turpentine, will mix, and yet refuse to amalgamate with any other varnish less boiled than itself; therefore it requires a nicety which is only to be learned from practice. This varnish is chiefly intended for the use of japanners, cabinet painters, and coach painters.

CARRIAGE VARNISH.—*Quick Drying.*—8 lb. of fine pale gum anime, 2 gal. of clarified oil, 3½ gallons of turpentine; to be boiled four hours. This, after being strained, is put into the two former pots, and well mixed together; its effect is to cause the whole to dry quicker and firmer, and enable it to take the polish much sooner.

Common Body Varnish for Carriages.—8 lb. of the best African copal, 3 gallons of clarified oil, 3½ gallons of turpentine; boiled four hours, or until stringy; mixed and strained, will produce about 5½ gallons. 8 lb. of the best gum anime, 2 gallons of clarified oil, 3½ gallons of turpentine; boiled as usual; mixed and strained hot, and put into the former pot of African gum varnish. Put two pots of this anime varnish to one of copal; it will dry quicker and harder than the best body copal, and will polish very soon, but not wear either so well or so long.

Best Pale Carriage Varnish.—8 lb of 2nd sorted African copal, 2½ gallons of clarified oil; boil till very stringy. ¼ lb. of dried copperas, ¼ lb. of litharge; 5½ gallons of turpentine; strained. 8 lb. of second sorted gum anime, 2½ gallons of clarified oil; ¼ lb. of dried sugar of lead, ¼ lb. of litharge; 5½ gallons of turpentine; mix with the first while hot. This varnish will dry hard, if well boiled, in four hours in summer, and six in winter. As its name denotes, this is intended for the varnishing of the wheels, springs, and carriage parts of coaches, chaises and so on; also it is that description of varnish whish is generally sold to and used by house painters and decorators, as from its drying quality and strong gloss it suits their general purposes well.

Second Carriage Varnish.—8 lb. of 2nd sorted gum animi; 2¾ gallons of fine clarified oil; 5½ gallons of turpentine; ¼ lb. of litharge, ¼ lb. of dried sugar of lead, ¼ lb. of dried copperas; boiled and mixed as before. When three runs are poured into the boiling pot, the regular proportion of driers put in, and well boiled, this varnish will dry hard and firm in four hours in winter, and in two in summer; it is principally intended for varnishing dark carriagework or black japan, and is also used by house painters for dark work.

WAINSCOT VARNISH (1) 8 lb. of 2nd sorted gum anime, 3 gallons of clarified oil, ¼ lb. of litharge, ¼ lb. of dried copperas, ¼ lb. of dried sugar of lead, 5½ gallons of turpentine; to be all well boiled until it strings very strong, and then mixed and strained. Where large quantities are required, it will always be found best to boil off the three runs in the boiling pot. This varnish is principally intended for house painters, grainers, builders and japanners: it will dry in two hours in summer, and in four in winter.

MAHOGANY VARNISH (1) is either made in the same proportions, with a little darker gum; otherwise it is wainscot varnish, with a small portion of gold size.

(2) Put in a bottle 2 oz. gum sandarach, 1 oz. shellac, ½ oz. gum bengamin, 1 oz. Venice turpentine, and a pint of spirits of wine. Colour red, with dragon's blood, or yellow with saffron. Stand in a warm spot till gum dissolves, when strain for use.

AMBER OIL VARNISH.—It is probable that amber makes the best wearing varnish, but it is wanting in elasticity, and should the wood swell or warp, or the metal expand and contract the varnish must suffer. The usual proportions are 1 part of yellow amber (made soluble), 1 part to 3 parts of boiled linseed oil and 1 to 2 parts of turpentine. The least oil makes the best wearing varnish but the least elastic, while the greater the oil the more elastic the varnish is, but the special wearing quality is decreased. The varying quantity of turpentine does not affect the quality, it is used according to whether the varnish is required stiff or very fluid.

Elasticity in varnish usually being a desirable quality, the wearing value of amber can be obtained in a considerable degree with elasticity by making the following mixed varnish.

Amber and Copal Varnish.—1 part amber (solubilised), 1 part copal, 2 parts boiled linseed oil, 4 parts turpentine. All by weight.

Pale Amber Varnish.—Fuse 6 lb. of fine-picked, very pale, transparent amber in the gum-pot, and pour in 2 gallons of hot clarified oil. Boil it until it strings very strong. Mix with 4 gallons of turpentine. This will be as fine as body copal, will work free, and flow well upon any work it is applied to; it becomes very hard, is durable, and is excellent to mix in copal varnishes, to give them a hard and durable quality. Amber varnish will always require a long time before it is ready for polishing.

DAMMAR VARNISH.—Gum dammar, 10 parts; gum sandarach, 5; gum mastic, 1. Digest at a low heat, occasionally shaking with spirits of turpentine, 20 parts. Add spirits of turpentine until of the consistence of syrup.

MASTIC VARNISH.—1 pint spirits of turpentine, and 10 oz. of the clearest gum mastic. Set it in a sand bath till it is all dissolved, then strain it through a fine sieve, and it is ready for use; if too thick, thin with spirits of turpentine.

LINSEED-OIL VARNISH.—Boil linseed oil, 60 parts, with litharge, 2 parts, and white vitriol, 1 part, each finely powdered, until all water is evaporated. Then set by. Or, rub up borate of manganese, 4 parts, with some of the oil, then add linseed oil, 3000 parts, and heat to boiling.

TURPENTINE VARNISH.—(*a*) To 1 pint of spirits of turpentine add 10 oz. clear resin pounded; put in a tin can on a stove, and let it boil for half an hour. When the resin is all dissolved, let it cool, and it is ready for use.

(*b*) Turpentine varnish consists of 4 lb. common (or bleached) rosin dissolved in 1 gal. oil of turpentine, under slight warmth. It is used for indoor painted work, and also to add to other varnishes to give them greater body, hardness, and brilliancy.

OAK VARNISH. *Cheap.*—(1) Clear pale resin, 3½ lb.; oil of turpentine, 1 gal.; dissolve. It may be coloured darker by adding a little fine lampblack.

(2) 10 gal. boiled oil substitute, 2½ gal. clarified linseed oil, 3 gal American turps, 30 lb. ground amber resin. Have both the oils boiling, run down the resin, add the boiling oils, cool down and then add the turpentine. Strain.

Hard Church.—(1) 10 lb. boiled linseed oil, 11 lb. American turps, 3 lb. medium gum kauri, 4½ lb. dark gum kauri.

(2) 16 lb. gum kauri, run this and mix with 6 gal. of linseed oil. Boil until it strings well. Allow to cool, then add 12 gal. of turpentine. This is best suited for interior work.

Quick.—4 lb. boiled linseed oil, 24 lb. American turpentine, 17 lb. dark gum kauri.

Pale.—(1) For good cabinet work. 24 lb. gum copal. Run this and mix with 9 gal. of linseed oil. Add ¼ oz. each of litharge, dried copperas and dried sugar of lead. Well boil the whole, then allow to cool and thin with 18 gal. of turpentine. Strain.

(2) 36 lb. gum kauri, 12 lb. copal, 4 lb. litharge, 10 gal. raw linseed oil, 9 gal. turpentine.

Dark.—13 lb. gum kauri, 1 lb. flake litharge, 1 lb. sulphate of zinc, 3 gal. raw linseed oil, 2⅓ gal. turpentine.

Copal Varnishes.—(1) Best Body Copal Varnish. — Fuse 8 lb. fine African gum copal; add 2 gal. clarified oil. Boil very slowly for 4 or 5 hours till quite stringy, and mix with 3½ gal. turpentine. This is used for the body part of coaches, and for other objects intended to be polished. The above makes the palest and best copal varnish, possessing great fluidity and pliability, but it is very slow in drying, and, for months, is too soft to polish. Driers are therefore added, but they are injurious. To avoid the use of driers, gum animi is used instead of copal, but it is less durable and becomes darker by age. The copal and animi varnishes are sometimes mixed; 1 pot of the latter to 2 of the former for a moderately quick drying varnish of good quality, and 2 pots of animi to 1 of the copal for quicker drying varnish of common quality.

COMMON VARNISH.—(*a*) This varnish is intended for protecting surfaces against atmospheric exposure. It has been used for coating wood and iron work with great advantage. Take 3 lb. of resin and powder it, place it in a tin can, and add 2½ pints of spirits of turpentine, well shake, and let it stand, occasionally shaking it, for a day or two. Then add of boiled oil 5 qt., well shake together, and allow it to stand in a warm room till clear. The clear portion is decanted and used, or reduced with spirits of turpentine until of the proper consistence.

(*b*) Digest shellac, 1 part; with alcohol, 7 or 8 parts.

COLOURLESS VARNISH, *with Shellac.*—Dissolve 2½ oz. of shellac in a pint of rectified spirits of wine; boil for a few minutes with 5 oz. of well-burnt and recently-heated animal charcoal. A small portion of the solution should then be filtered, and if not colourless, more charcoal added; when all the colour is removed, press the liquor through a piece of silk, and afterwards filter through fine blotting paper. This kind of varnish should be used in a room at 60° F., perfectly free from the least dust. It dries in a few minutes, and is not liable afterwards to chill or bloom. It is particularly applicable to drawings and prints that have been sized, and may be advantageously used upon oil paintings which are thoroughly hard and dry, as it brings out the colours with the purest effect.

HARD SPIRIT VARNISH. *White.*—1. Gum sandarach, 1 lb.; clear turpentine, 6 oz.; rectified spirits (65 over proof), 3 pints; dissolve.

2. Mastic, in tears, 2 oz.; sandarach, 8 oz.; gum elemi, 1 oz.; Chio turpentine, 4 oz.; rectified spirit (65 over proof), 1 qt. Used on metals; polishes well.

3. Gum mastic, 4 oz.; gum juniper, ½ lb.; turpentine, 1 oz.; spirits of wine, 4 pints; mix together.

4. White hard spirit varnish may be made by dissolving 3½ lb. gum sandarach in 1 gal. spirits of wine; when solution is complete, add 1 pint pale turpentine and shake well together.

Brown.—1. Sandarach, 4 oz.; pale seed-lac, 2 oz.; elemi, 1 oz.; alcohol, 1 qt.; digest with agitation till dissolved, then add Venice turpentine, 2 oz.

2. Gum sandarach, 3 lb.; shellac, 2 lb.; rectified spirit (65 over proof) 2 gal.; dissolve, add turpentine varnish, 1 qt.; agitate well and strain. *Very fine.*

3. Seed-lac and yellow resin, of each 1½ lb.; rectified spirit, 2 gal.

4. Gum juniper, 6 oz.; shellac, 6 oz.; salt of tartar, ⅛ oz.; Venice turpentine, 1⅛ oz., and 4 pints of spirits of wine mixed together.

5. Brown hard spirit varnish is made like the white, but shellac is substituted for the sandarach. It will bear polishing.

WHITE VARNISH.—1. Tender copal, 7½ oz.; camphor, 1 oz.; alcohol of 95 per cent., 1 qt. Dissolve, then add mastic, 2 oz.; Venice turpentine, 1 oz. Dissolve and strain. Very white, drying, and capable of being polished when hard. Used for toys.

2. Sandarach, 8 oz.; mastic, 2 oz.; Canada balsam, 4 oz.; alcohol, 1 qt. Rectified spirits of wine, 1 qt.; gum sandarach, 10 oz.; gum mastic, 2 oz.; gum anime, ½ oz. Dissolve in a clean can, with gentle heat. Agitate well when the gums are dissolved; strain through a lawn sieve.

DARK VARNISH FOR LIGHT WOODWORK.—Pound up and digest shellac, 16 parts; gum sandarach, 32; gum mastic, 8; gum elemi, 8; dragon's blood, 4; annatto, 1, with white turpentine, 16; and alcohol, 256. Dilute with alcohol if required.

SOFT BRILLIANT VARNISH.—Sandarach, 6 oz.; elemi (genuine), 4 oz.; anime, 1 oz.; camphor, ½ oz.; rectified spirit, 1 qt.; as before.

SEALING-WAX VARNISH.—Dissolve sealing-wax in spirits of wine, and apply the solution (well shaken up) with a soft brush; the spirits of wine will evaporate, leaving an even coating of sealing-wax.

GREEN TRANSPARENT VARNISH.—Grind a small quantity of Chinese blue and chromate of potash together, and mix them thoroughly in common copal varnish thinned with turpentine. The blue and the chromate must be ground to an impalpable powder, and the tone of colour varied with the amount of each ingredient used. A yellow-green requires about twice the quantity of the chromate of potash to that of the Chinese blue.

ANILINE VARNISHES.—Prepare a spirit varnish by dissolving sandarach in spirits of wine, and add to this the aniline colour previously dissolved in spirit. Intense colours may be obtained. The objects should be warmed, and, if possible, they should be dipped in the varnish.

GOLDEN VARNISH.—(*a*) Pulverize 1 drachm of saffron and ½ drachm of dragon's blood, and put them into 1 pint spirits of wine. Add 2 oz. of gum shellac and 2 drachms of Socotrine aloes. Dissolve the whole by gentle heat. Yellow painted work varnished with this mixture will appear almost equal to gold.

(*b*) Digest shellac, 16 parts; gum sandarach and mastic, of each 3; crocus, 1; gum gamboge, 2; all bruised, with alcohol, 144. Or, digest seed-lac, sandarach, mastic, of each 8 parts; gamboge 2; dragon's blood, 1; white turpentine, 6; turmeric, 4; bruised, with alcohol, 120.

BOILING WATER, TO RESIST.—Linseed oil, 1½ lb.; amber, 1 lb.; litharge pulverised, 5 oz.; white lead pulverised, 5 oz.; minium, 5 oz. Boil the linseed oil in an untinned copper vessel, and suspend in it the litharge and the minium in a small bag, which must not touch the bottom of the vessel. Continue the ebullition until the oil has acquired a deep brown colour; then take out the bag and put in a clove of garlick; this is to be repeated seven or eight times, the ebullition being always continued. Before the amber is added to the oil, it is mixed with 2 oz. of linseed oil, and melted over a fire that is well kept up. When the mass is fluid, it is to be poured into the linseed oil; this mixture is to be boiled and stirred continually for 2 or 3 minutes; afterwards filter the mixture, and preserve in bottles tightly corked. When this varnish is used, the wood must be previously well polished, and covered with a thin coat of soot and spirits of turpentine. When this coat is dry, some of the varnish may be applied, which should be distributed equally on every part with a small fine sponge. This operation is to be repeated 4 times, being always careful that each coat be well dried first. After the last coat of varnish, the wood must be dried in an oven and afterwards polished.

TABLE VARNISH.—(1) Oil of turpentine, 1 lb.; beeswax, 2 oz.; colophony, 1 drachm. (2) Dammar resin, 1 lb.; spirits of turpentine, 2 lb.; camphor, 200 grains. Digest the mixture for twenty-four hours. The decanted portion is fit for immediate use.

FURNITURE.—1. Shellac, 1½ lb.; naphtha, 1 gallon; dissolve, and it is ready without filtering.

2. Shellac, 12 oz.; copal, 3 oz. (or an equivalent of varnish); dissolve in 1 gallon of naphtha.

3. Shellac, 1½ lb.; seed-lac and sandarach, each 4 oz.; mastic, 2 oz.; rectified spirit, 1 gallon; dissolve.

4. Shellac, 2 lb.; benzoin, 4 oz.; spirit, 1 gallon.

5. Shellac, 10 oz.; seed-lac, sandarach, and copal varnish, of each 6 oz.; benzoin, 3 oz.; naphtha, 1 gallon.

To darken, benzoin and dragon's blood are used, turmeric and other colouring matters are also added; and to make it lighter it is necessary to use bleached lac, though some endeavour to give this effect by adding oxalic acid to the ingredients; it, like gum arabic, is insoluble in good spirit or naphtha. For all ordinary purposes the first form is best and least troublesome, while its appearance is equal to any other.

White.—White wax, 6 oz.; oil of turpentine, 1 pint; dissolve by a gentle heat. Or white wax, 6 parts; petroleum, 48; applied to the work while warm, allowed to cool, then polished by rubbing with a coarse cloth.

COACH MAKERS' BLACK VARNISH.—Gum amber 16 oz.; melt in ½ pint of boiling hot linseed oil: add 3 oz. of asphaltum, and 3 resin; mix thoroughly over a fire, and add when cooling 1 pint of oil of turpentine slightly warm.

ASPHALTE VARNISH.—Boil coal tar until it shows a disposition to harden on cooling; this can be ascertained by rubbing a little on a piece of metal. Then add about 20 per cent. of lump asphalte, stirring it with the boiling coal tar until all the lumps are melted, when it can be allowed to cool and kept for use. This makes a very bright varnish for sheet metals, and is cheap and durable.

IRONWORK, VARNISH FOR.—(1) Dissolve in about 2 lb. of tar oil, ½ lb. of asphaltum, and a like quantity of pounded resin, mix hot in an iron kettle, care being taken to prevent any contact with the flame. When cold the varnish is ready for use. This varnish is for out-door wood and iron work.

(2) The following is recommended by Matheson as very effective: 30 gal. of coal tar, fresh, with all its naphtha retained; 6 lb. tallow; 1½ lb. rosin; 3 lb. lampblack; 30 lb. fresh slaked lime, finely sifted—mixed intimately and applied hot. When hard, this varnish can be painted on by ordinary oil paint if desired.

(3) Fuse 3 lb. Egyptian asphaltum; when it is liquid, add ½ lb. shellac and 1 gal. turpentine.

Varnish for Iron Patterns.—A good varnish for iron is made as follows: Take oil of turpentine and drop into it, drop by drop, strong commercial oil of vitriol; the acid will cause a dark syrupy precipitate in the oil of turpentine; keep adding drops of vitriol until the precipitate ceases taking place, then pour out the liquid and wash the syrupy mass with water, and it is ready for use. Heat the iron to be varnished to a gentle heat, apply the syrupy product and allow it to dry.

Ironwork Black.—Put 48 lb. of foreign asphaltum into an iron pot, and boil for 4 hours; during the first 2 hours introduce 7 lb. of red-lead, 7 lb. of litharge, 3 lb. of dried copperas, and 10 gal of boiled oil; add one 8-lb. run of dark gum, with 2 gal. of hot oil. After pouring the oil and gum continue the boiling 2 hours, or until it will roll into hard pills, like japan. When cool, thin it off with 30 gal. of turpentine, or until it is of a proper consistence.

Iron and Steel.—Dissolve 10 parts of clear grains of mastic, 5 camphor, 15 sandarach, and 5 of elemi, in a sufficient quantity of alcohol, and apply without heat.

BLACK JAPAN is made after the manner of the gold size. Put 6 gal. of raw linseed oil into the set pot; boil it with a very slow fire. Have a 10-gal. cast-iron pot, with two handles or ears; this pot will fit into the plate of the boiling furnace, into which put 10 lb. of Egyptian asphaltum, and keep under it a good regular fire all the time of fusion. During the time the asphaltum is fusing, have 2 gal. of oil getting hot to mix it with as soon as it is sufficiently melted. After it is oiled, leave it on the fire about ten minutes; then pour it into the set pot. Carry it out of doors, and with a handful of hay or straw clear it out, and afterwards wash it out with turpentine washings, and dry it with a rag. Proceed and finish three more separate runs like the first, until there are four runs in the set pot, that is, 40 lb. of asphaltum and 14 gal. of raw linseed oil; then introduce exactly the same driers as for the gold size, and in the same manner. Keep a regular, but moderate fire, so that the boiling continues at a moderate heat for four hours from the last run being poured in the set pot; then draw, and put out the fire for that day. Next morning, as soon as it can be brought to a boil, try it upon a bit of glass; if it but strings strongly, it will not do; it must be boiled so strong that when a piece is pinched from off the glass, after it has been left to cool, it will roll into a hard pill between the finger and thumb. When it forms hard, and scarcely sticks to the fingers, it is then boiled enough. Put out the fire, as directed before. Leave it one hour and a half before mixing. When cold enough, mix it with 30 gal., at least, of turpentine, and strain it. If it is too thick when cold, heat and introduce as much turpentine as will bring it to a proper consistence. The japan will dry in 6 hours in summer, and 8 in winter. It is principally intended for and used by coach makers, japanners, or painters, and should be kept at least six months before it is used.

Another Black Japan is made by putting into the set pot 48 lb. of Naples asphaltum; as soon as it is melted, pour in 10 gal. of raw linseed oil. Keep a moderate fire, and fuse 8 lb. of dark gum anime in the gum pot: mix it with 2 gal. of oil, and pour it into the set pot. Afterwards fuse 10 lb. of dark or sea amber in the iron pot. When it appears completely fused, pour in 2 gal. of hot oil, and pour it into the set pot; continue the boiling for three hours longer, and during that time introduce the same quantity of driers as before directed; draw out the fire, and let it remain until morning; then boil it until it rolls hard; leave it to cool, and afterwards mix with turpentine. This japan will appear in colour like the other; but when applied on work, it will dry more hard, compact and glossy, and will not rub down or polish so soon as the other, which is occasioned by the toughness and durability of the amber.

BRUNSWICK BLACK. *Best.*—In an iron pot, over a slow fire, boil 45 lb. of foreign asphaltum for at least 6 hours, and during the same time boil in another iron pot 6 gal. of oil which has been previously boiled; during the boiling of the 6 gal. introduce 6 lb. of litharge gradually, and boil until it feels stringy between the fingers; then ladle it into the pot containing the boiling asphaltum. Let both boil until, upon trial, it will roll into hard pills; then cool, and mix with 25 gal. of turpentine, or until it is of a proper consistence.

Common.—Put 28 lb. of common black pitch, and 28 lb. of common asphaltum made from gas tar, into an iron pot, boil both for 8 or 10 hours, which will evaporate the gas and moisture; let it stand all night, and early next morning, as soon as it boils, put in 8 gal. of boiled oil; then introduce gradually 10 lb. of red-lead and 10 lb. of litharge, and boil for 3 hours, or until it will roll very hard. When ready for mixing, introduce 20 gal. of turpentine, until of a proper consistence. This is intended for engineers, founders, or ironmongers; it will dry in half an hour, or less, if properly boiled.

BLACK VARNISH FOR STRAW HATS.—Best black sealing wax, ½ oz.; rectified spirits of wine, 2 oz.; powder the sealing wax, and put it with the spirits of wine into a phial, digest them in a sand bath, or near a fire till the wax is dissolved; lay on warm with a fine soft hair brush before a fire, or in the sun.

POLISHED METAL, VARNISH FOR.—1. Take bleached shellac, pounded in a mortar; place the bruised fragments into a bottle of alcohol until some shellac remains undissolved; agitate the bottle and contents frequently, and let the whole stand till clear; pour off the clear fluid. This forms the varnish. Warm the metal surface and coat with a camel-hair brush. If not perfectly transparent, warm the varnished surface before a fire or in an oven until it becomes clear. Common orange shellac answers equally well, and for large surfaces even better, as it is more soluble than the bleached variety, and coats more perfectly, but care must be taken not to use the varnish insufficiently diluted.

2. Digest 1 part of bruised copal in 2 parts of absolute alcohol; but as this varnish dries too quickly it is preferable to take 1 part of copal, 1 part of oil of rosemary, and 2 or 3 parts of absolute alcohol. This gives a clear varnish as limpid as water. It should be applied hot, and when dry it will be found hard and durable.

3. Mix equal quantities of Canada balsam with very clear spirits of turpentine, until the whole is of the consistence of ordinary varnish, which can be determined by constantly shaking and allowing to settle. This may be applied without warming the varnish or the metal.

GILT ARTICLES.—Gumlac, 125 parts; gamboge, 125; dragon's blood, 125; annatto, 125; saffron, 32. Dissolve each resin in 1000 parts by measure, of absolute alcohol; two separate mixtures must be made with the dragon's blood and annatto, in 1000 parts of such alcohol; and a proper proportion of each should be added with the gamboge to the varnish, according to the shade of colour required.

SILVER.—Gum elemi, 30 parts; white amber, 45; charcoal, 30; spirits of turpentine, 375. Used in a heated state; the metal to which it is to be applied being also heated.

WATERPROOF GOODS.—Let a ¼ lb. of india-rubber, in small pieces, soften in ½ lb. of oil of turpentine, then add 2 lb. of boiled oil, and boil for 2 hours over a slow fire. When dissolved, add 6 lb. of boiled linseed oil, and 1 lb. of litharge, and boil until an even liquid is obtained. Applied warm.

INDIA-RUBBER VARNISH.—(1) 2 oz. india-rubber, finely divided, placed in a phial, and digested in a sand bath, with ¼ lb. of camphene, and ¼ oz. of naphtha. When dissolved, add 1 oz. of copal varnish, which renders it more durable.

2. Digest in a wide-mouth glass bottle 2 oz. of india-rubber in shavings with 1 lb. of oil of turpentine, during two days, without shaking, then stir up with a wooden spatula. Add another lb. of oil of turpentine, and digest, with frequent agitation, until all is dissolved. Mix 1½ lb. of this solution with 2 lb. of white copal-oil varnish, and 1½ lb. of boiled linseed-oil shake and digest in a sand-bath until they have united into a good varnish.

3. 4 oz. india-rubber in fine shavings dissolved in a covered jar by means of a sand bath, in 2 lb. of crude benzole, and then mixed with 4 lb. of hot linseed-oil varnish and ½ lb. of oil of turpentine. Dries well.

GAS BALLOONS.—Take india-rubber and dissolve it in 5 times its weight of spirits of turpentine, keeping them some time together, then boil gently 1 part of this solution with 8 parts of boiled linseed-oil for a few minutes, strain and set aside to cool. It must be applied warm.

GUTTA-PERCHA VARNISH.—Clean a quarter of a pound of gutta percha in warm water from adhering impurities, dry well, dissolve in 1 lb. of rectified resin oil, and add 2 lb. of linseed-oil varnish, boiling hot.

GLASS.— Pulverise a quantity of gum adragant, and let it dissolve for 24 hours in the white of eggs, well beat up; then rub it gently on the glass with a soft brush.

Varnish used when Acid Etching on Glass.—Digest in turpentine 2 oz. wax, ½ oz. asphalte, and 1 oz. mastic.

BLACK LEATHER VARNISH. — (1) Durable leather varnish is composed of boiled linseed oil, in which a drier, such as litharge, has been boiled. It is coloured with lampblack. This varnish is used for making enamelled leather. (2) Digest shellac, 12 parts; white turpentine, 5; gum sandarach, 2; lampblack, 1; with spirits of turpentine, 4; alcohol, 96.

TO IMITATE GROUND GLASS.—

Sandarach	18 parts
Mastic	4 ,,
Ether	200 ,,
Benzole . . .	80 to 100 ,,

VIOLINS. — (1) Coarsely-powdered copal and glass, each 4 oz.; alcohol, 64 o.p., 1 pint; camphor, ½ oz.: heat the mixture with frequent stirring in a water bath, so that the bubbles may be counted as they rise until solution is complete, and when cold decant the clear portion. When oil varnish is used it is made as for *Artist's Virgin Copal.*

(2) When varnishing a new violin, an important detail is the preparation of the surface. First go over it with No. 1 glass-paper to free it from all scratches, after which lightly sponge it over with a sponge slightly damp with water. When the surface is dry it will be found to be quite rough, and this requires taking off with No. 0 glass-paper. Smooth it well, then damp again, and when dry, rub quite smooth once more. The wood is now ready for colouring and varnishing; but it is not desirable to stain the woodwork of violins, as better results are obtained by using a coloured varnish. Take 1 pint of good copal varnish and 1 gill (¼ pint) of turpentine. Heat these very carefully over a dull fire (a water-bath is best) letting them get scalding hot. Test the heat, or it may get high enough to fire the mixture. Varnish over the whole of the woodwork with this, using a stiff brush and rubbing it well in. While it is wet take a pad of cotton wool covered with fine cotton or linen rag, moisten this with turpentine, and then rapidly clean off as much of the varnish from the violin as possible. Now prepare an alcohol varnish as follows:—Take a gill of methylated spirit and colour it with red sanders wood and turmeric. Take another gill of spirit and dissolve 1 oz. of gum sandarach in it. Mix the two lots together and add one tablespoon of Venice turpentine and 1 oz. of white shellac. When all are dissolved and incorporated filter through very fine muslin. This makes an elastic varnish of assistance to the tone and affording the deep amber colour always desired. Use a full-sized camel hair brush for laying on this varnish, working length-ways of the instrument, but avoiding going over the same place twice or making streaks. It is a quick drying varnish. Four coats are desirable, rubbing down with finest pumice powder and water, applied with a woollen rag, after each coat. After the last coat of varnish is on, making a good body, rub down with pumice powder and water, then thoroughly clean off all pumice and carefully dry all parts. For the final polish use tripoli and water, or crocus and linseed oil on a rag, and then rub smartly with the ball of the hand. The result should be a glossy surface giving every satisfaction.

(3) Re-varnishing a violin is a process identical with that just described except that the first process is to sandpaper the old varnish and colouring

entirely off. When the wood is quite bare proceed as with (2).

(4) To varnish a violin a self colour the wood surface is prepared as in (2), or in the case of an old violin the varnish and colouring already on must be sand-papered off as with (3). When this is done apply the first coat of copal varnish and turpentine and rub this off (as already explained), then make a spirit varnish without the colouring matter (turmeric and red sanders) and apply this. Four coats is considered the least number for good results, and each coat must be allowed to get quite hard, then be rubbed down, before applying the next. After the last coat rub down as with the preceding coats, then polish with rouge (or crocus) and linseed oil, finishing with the ball of the hand. Putty powder or wheat flour can be used when the last hand polish is taking place.

PRINTS, ENGRAVINGS OR MAPS.—1. Boil Chio turpentine till brittle, powder and dissolve in oil of turpentine.

2. Canada balsam and clear white resin, of each 6 oz., oil of turpentine, 1 qt.; dissolve.

3. Digest gum sandarach, 20 parts; gum mastic, 8; camphor, 1; with alcohol, 48. The map or engraving must previously receive one or two coats of gelatine size.

4. *Mastic Picture Varnish.*—Dissolve (cold) 5 lb. gum mastic in 2 gal. of turpentine.

5. *Map Varnish.*—Dissolve (cold) 2½ lb. gum dammar in ½ gal. of turpentine.

6. *Crystal Varnish for Engravings.* Equal parts of pale Canada balsam and rectified oil of turpentine.

7. *Crystal Paper Varnish.*—5½ lb. gum dammar, 1 gal. turpentine.

8. *Paper Varnish for General Purposes.*—7 lb. No. 1 gum dammar, 2 lb. colophony rosin, 1½ gal. turpentine.

COLOURED DRAWINGS.—Canada balsam, 1 oz.; spirits of turpentine, 2 oz. Mix them together. Before this composition is applied, the drawing or print should be sized with a solution of isinglass in water, and when dry apply the varnish with a camel-hair brush.

PAINTINGS AND PICTURES. — 1. Honey, 1 pint; the whites of 24 fresh eggs; 1 oz. of isinglass, 20 gr. of hydrate of potassium, ½ oz. common salt; mix together over a gentle heat of 80° or 90° F.; be careful not to let the mixture remain long enough to coagulate the albumen of the eggs; stir the mixture thoroughly, then bottle. Take one tablespoonful of the varnish and add to it half a tablespoonful of good oil of turpentine, then spread on the picture as soon as mixed.

2. Digest at a slow heat gum sandarach, 2 parts; gum mastic, 4; balsam capivi, 2; white turpentine, 3; with spirits of turpentine, 4; and alcohol 50-56 parts.

3. Boil 5 parts bitter apple, freed from the seeds and cut, with rain-water 50 parts, down to one-half. Strain and dissolve in the liquor gum arabic, 8 parts; rock candy, 4; and add 1 of alcohol. Let it stand for some days, and filter.

4. Pure linseed oil, to which a small quantity of sugar of lead, ground fine, has been added.

5. Take equal quantities of linseed oil and oil of turpentine, thicken by exposure to the sun and air until it becomes resinous and half evaporated, then add a portion of melted beeswax.

Varnishing pictures should always be performed in fair weather, and out of any current of cold or damp air.

LAC-WATER VARNISH.—Pale shellac, 5 oz.; borax, 1 oz.; water, 1 pint. Digest at nearly the boiling point till dissolved, then strain. An excellent vehicle for water colours, inks, etc., and a varnish for prints is made thus of bleached lac. When dry, it is transparent and waterproof.

TRANSFER VARNISH, *for Diaphanie, Engravings, etc.*—1. Pale Canada balsam and rectified oil of turpentine, equal parts. 2. Mastic in tears and sandarach, each 4 oz.; rectified spirit, 1½ pints; dissolve, and add pale

Canada balsam ½ pint. Melt the balsam with a gentle heat, mix with the other ingredients and agitate violently. No. 1 is also termed *Crystal Varnish.*

GOLD OR SILVER PAINTS. — Mix together 1 gal. amyl acetate, 1 gal. benzol, ½ gal. acetone. In this dissolve 10 oz. of pyroxyline (celluloid). Add the metallic powder.

BOOKBINDERS' VARNISH.—(*a*) 6 oz. mastic, in drops; 3 oz. coarsely-pounded glass, separated from the dust by a sieve; 32 oz. spirits of wine of 40°. Place the ingredients in a sand bath over a fire, and let them boil, stirring them well. When thoroughly mixed introduce 3 oz. spirits of turpentine, boil for half an hour, remove from fire, cool and strain through cotton cloth. (*b*) 3 pints of spirits of wine of 40°; 8 oz. sandarach; 2 oz. mastic, in drops; 8 oz. shellac, and 2 oz. Venice turpentine. Prepare as for (*a*). Apply lightly on the book with a piece of cotton wool, a small sponge or a brush.

Japanner's Gold Size.—To make 40 gal. of gold size, put 10 gal. of oil into the iron set pot, Fig. 284, make a good fire under it, and boil for two hours; then introduce 7 lb. of dry red-lead, 7 lb. litharge, and 3 lb. of copperas, by sprinkling a little at a time; let the oil keep boiling all the time, not in too great a heat. During the time of putting in the driers, keep stirring them from the bottom of the pot, and have the large iron ladle ready to cool it down if it should appear to rise too high; have also at hand an empty pot—the copper boiling pot will do—into which immediately ladle part of the boiling oil, if it cannot otherwise be kept in the pot, while the assistant is damping the fire with wet sifted ashes, of which there always ought to be a wheelbarrowful at hand, in case of an accident.

When the oil has boiled about three hours, and the driers are all in, fuse in the gum-pot 10 lb. of gum anime; and during the time of fusing, heat 2 gal. of raw linseed oil in the copper pouring jack, by placing it on the plate of the gum furnace. After the oil has been poured to the gum, and as soon as it appears boiled clear, take the gum-pot from the fire; let it cool for a few minutes, then pour it into the oil in the set pot. Wash out the gum-pot, and proceed with another run in the same way.

When both runs of gum are in the set pot, there are altogether 14 gal. of oil, 20 lb. of gum, and 17 lb. of driers; increase and keep up a regular fire in front of the furnace, that it may be drawn out in a moment if it should be necessary. The gold size will soon throw up a frothy head on the surface, which must be kept down by constantly plying with the ladle when it is likely to rise within four inches of the pot-edge. In about five hours from the beginning of the oil boiling, it will become stringy; but the boiling must continue until it hangs to the ladle, appears quite stringy, yet drops in lumps. When tried upon the glass, if it feels sticky and strings strongly, then it is boiled enough. Draw out the fire, sprinkle it with plenty of water; leave not a spark of fire in the varnish house—not even a lighted pipe of tobacco.

While the maker is cooling down the pot, let the assistant have ready at the door 30 gal. of turpentine, fill the pouring pot ready, and have all the doors open. Endeavour to cool it as fast as possible, as it will require at the least one hour and a quarter after the fire has been put out before it will be ready to mix. When the mixing commences, continue the pouring without intermission, until all the froth at the surface disappears, never stirring it until the turpentine is all in. If pouring in the turpentine has commenced while it is too hot, there will be a great loss of turpentine by evaporation; but that will not injure the quality of the gold size.

Place the carrying tin close to the side of the pot, lay on the tin saddle, and strain off as quickly as possible. When all the gold size is out, pour into the set pot about 3 gal. of turpentine washings, and with the swish, wash down the pot as quickly as possible; and if the pot is still so hot as to evaporate the turpentine, ladle it out into the washings again, and pour in about three gal. of raw linseed oil; and with a palette knife scrape it all round, washing and cleaning it down with a rag until it is quite cleansed all round, then ladle out the oil, and wipe it completely clean and dry. The gold size ought to dry in from fifteen to twenty-five minutes, and in fourteen days it is ready for use. Experienced makers can make gold size that will dry in five minutes, but that requires great practice.

Photographic Varnishes.—A solution of shellac in methylated spirit forms the basis of varnish, and a simple varnish so made will answer for all rough work; but where delicate results are wanted, it must be paler in colour, and for this purpose use "bleached shellac." Bleached shellac dissolved in spirit, however, is not nearly so hard and tenacious as that from the orange shellac. A good strong coating of it is readily scratched by the finger-nail—a *contretemps* so likely to occur in printing that such a varnish cannot be recommended. White shellac is made by dissolving ordinary shellac in caustic alkali, and then treating the solution with chlorine, which at one and the same time decolorises and precipitates it. This process, though it produces a pale resin of great value for many economical purposes, causes the resin to lose many of those properties that specially fit orange lac for use in photographic varnish. One of the peculiarities of white lac varnish is the frequency with which it dries into a multitude of fine ridges, which no rocking of the plate to and fro during draining and drying will prevent. But for paleness of colour in the coating obtained from it nothing can be better, and in a mixture of the two resins—that is, the bleached and the unbleached—the objectionable qualities of both seem either covered or greatly minimised. This mixture in suitable proportions constitutes the chief part of the varnish recommended.

Experimenters with "bleached," or as it is often called, "white lac," must know that unless it be properly stored it practically loses its solubility in spirits of wine; and many cases of failure in varnish-making are caused through the purchaser being supplied with a sample that had become insoluble. Of course this would not be likely to occur in a place where the lac was in great demand; but many of our readers live in places where photographic—indeed, any rare—chemicals are most difficult to get, and when obtainable are not always in good condition. However, in the case of white lac, where the experimenter is ignorant of the appearance it should present, he can easily test a small quantity if he have any doubt in the matter. It should be crushed or pounded into small pieces before adding to the spirit, as even in the best samples a large proportion entirely insoluble always exists, and a clear solution must not be expected. Its solubility or the reverse is soon discovered by noticing whether the small particles begin to disintegrate, as it were, or retain their sharp outlines.

A good indication of insolubility is the outer layer of the round pieces or sticks turning semi-transparent. The plan usually adopted to prevent this change taking place is to keep the bleached lac in the dark and covered with water, when, if it remain so covered, it will retain its solubility in spirit for a lengthened period.

The third and last ingredient in this varnish is sandarach. It is well known by varnish-makers that, when resins are mixed and "blended," the character of the solution or varnish is not by any means of necessity an average of the characters of the resins taken separately, and such is the case with sandarach. This resin taken by itself gives a varnish that is quite useless from its brittleness, but when added to a shellac varnish it confers a portion of its own quality of brightness of surface, which it possesses in a high degree, but does not, in moderate quantity, tend to make it "rotten."

The formula for a varnish devised on the principles above enunciated is as follows :—

Palest orange shellac . .	2¾ oz.
Bleached lac	5½ oz.
Sandarach	½ oz.
Methylated spirit . . .	1 qt.

Bruise the bleached lac till reduced to small pieces. Powder the sandarach, and then add the whole to the spirit, putting in a few small pieces of glass to prevent the shellac caking at the bottom of the jar ; stir or well shake the whole from time to time, till it is evident that solution is complete. All that is then necessary is to set aside to clear, pour off the clear, supernatant fluid, and filter the rest. It is best to allow a month or two for subsidence, for the insoluble part occupies so large a space that much waste through evaporation, etc., is caused if an unnecessarily large quantity be passed through the filter.

(2) Quick-drying Varnish for Ferrotypes.—A very good and hard varnish used for negatives which have to stand far more handling than a ferrotype is composed of equal parts of white hard spirit varnish and alcohol. Warm the plate, and apply as collodion, pouring off the superfluous quantity ; slightly warm again, and on cooling, which takes place in a minute or two, a fine hard coat of varnish will be found—so hard that it can scarcely be scratched with the finger-nail. The process used for ferrotypes is very similar to that for glass positives, with the exception that a special kind of collodion should be used so as to produce a thin deposit with considerable detail.

(3) Elastic Dammar Varnish.—An elastic flexible varnish for paper, which may be applied without previously sizing the article, is prepared as follows : Crush transparent and clear pieces of dammar into small grains ; introduce a convenient quantity—say 40 gr.—into a flask, pour on it about 6 oz. acetone, and expose the whole to a moderate temperature for about 2 weeks, frequently shaking. At the end of this time, pour off the clear saturated solution of dammar in acetone, and add, to every 4 parts varnish, 3 of rather dense collodion ; the 2 solutions are mixed by agitation, the resulting liquid is allowed to settle, and preserved in well-closed phials. This varnish is applied by means of a soft beaver-hair pencil, in vertical lines. At the first application it will appear as if the surface of the paper were covered with a thin white skin. As soon, however, as the varnish has become dry it presents a clear shining surface. It should be applied in 2 or 3 layers. This varnish retains its gloss under all conditions of weather, and remains elastic ; the latter quality adapts it specially to topographical crayon drawings and maps, as well as to photographs. ('Pharm. Centralhalle.')

(4) For Prints.—Heat a piece of glass, and rub a little wax over it with a bit of cotton-wool. Pour water over the plate, and press the picture down upon it with a piece of filtering paper. When dry, the picture is removed, and will be found to possess a brilliant surface.

Removing Varnish from Prints.—1. Begin at the corner of the print by rubbing up the varnish with the fingers ; a fine white dust will be produced, which is the dry old varnish ; proceed all over the print, and wipe off this white dust with a rag. Repeat until the print has lost most or all of the old varnish. Now strain the print on a drawing-board, size with weak parchment size ; when dry, size again with the same size ; use the size half chilled ; when perfectly dry, apply mastic or other varnish.

2. Lay blotting-paper on the print, and saturate with pure spirit, which will dissolve, and the blotting-paper absorb the varnish. Change the blotting paper, and repeat as often as may be needful.

ETCHING VARNISHES.—White wax,

2 oz. ; black and Burgundy pitch, of each ½ oz. ; melt together ; add by degrees powdered asphaltum 2 oz., and boil till a drop taken out on a plate will break when cold, by being bent double two or three times between the fingers; it must then be poured into warm water and made into small balls for use.

Hard.—Linseed oil and mastic, of each 4 oz. ; melt together.

Soft.—Soft linseed oil, 4 oz. ; gum benzoin and white wax, of each ½ oz. ; boil to two-thirds.

* * *

VENTILATION

PRINCIPLES AND METHODS.

(*a*) THE following is extracted from a valuable paper, read by Arthur Rigg, C.E., before the Royal Society of Arts.

The movements of large volumes of air for purposes of summer or winter ventilation may be carried out generally in three different ways, already noted :—

1. By vacuum (drawing air out of a room).
2. By plenum (forcing air into a room).
3. By a combined plenum and vacuum system.

Furthermore, admission of fresh air may take place—

(*a*) At the floor of a room.

(*b*) At, or near, the top of a room.

(*c*) At intermediate levels.

Where special exits for foul air are provided, these may be situated at the top of a room for ascending currents, or at the floor of a room for the descending current system of ventilation.

The three systems of working with the six variations in admission or extraction of air give possibilities of great variety in the arrangements, which is very fortunate, as no hard or fast line can be maintained, for every position requires its own special consideration ; and once the correct general principles are firmly rooted in people's minds, their application to suit every variety of condition is comparatively a simple matter.

Vacuum System.—This, the commonest system of ventilation, when applied to large halls, requires a powerful suction ventilator, generally fixed in the top of a room ; and usually no provision whatever is made for an adequate supply of fresh air, consequently cold air is sucked underneath doors, flooding the floor with a layer of low temperature ; also through cracks and crannies, causing high velocity draughts, which travel great distances, and produce any amount of discomfort and injury to health.

In ordinary dwelling-rooms the fire acts like the ventilator in drawing air out of dwelling rooms. As a rule, the first draught of importance is that under the doorway, while leaky windows contribute their quota, and an altogether surprising amount of air is drawn through the solid walls. In an ordinary living-room, with a fireplace, an almost ideally perfect system of ventilation can be carried out by admitting fresh air in divided streams into the upper parts of such rooms, where it may mix with the warmer strata it finds there and gradually descend and pass away eventually up the chimney.

Innumerable buildings and large assembly rooms are ventilated on the pure vacuum system, and there is not a town of any moderate size in the kingdom which cannot furnish examples of this most barbarous arrangement. In London we have the School Board, and numerous schools; and nearly all the theatres come in the same category. Then such places as the United Service Institution theatre excel in the perverse ingenuity which does not allow a single sq. yd. of its area to be free from draughts; also such places as Prince's Hall, Piccadilly, the new "Empress" Rooms, and other places such as the meeting-rooms used by the British Association in the several towns they visit, and hosts of assembly rooms are deluged with cold air in this unscientific fashion. Sometimes, however, special inlets are provided for admission of fresh air in considerable volumes. When such inlets are made in the form of the well-known Tobin tube it is found that part of the air makes straight for the ventilator; while the remainder, having no velocity, tumbles in cold masses, by the action of gravity, upon the heads of the audience. Moreover, as there is no intimate mixture of the fresh supply with that already in the room, some parts of the room have their air unmoved and left in a condition of complete stagnation.

Tobin Tube.—Fig. 289 represents a section, and Fig. 290 an elevation of a Tobin tube, at the Royal Institution, Albemarle-street. It is of the most modern design and proportions, and its vertical flat inlet tube measures 12 in. by 3 in. Its total height above the floor is 5 ft. 3 in. The outlet is 20 in. wide at the back, and 18 in. at the front, with a seven in. wide opening at the top; provided with a thin wire netting as cover.

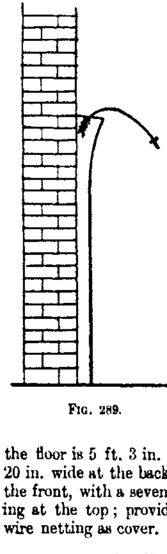
FIG. 289.

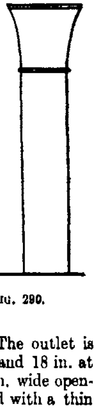
FIG. 290.

Thus the sectional area for inlet . } = 36 sq. in.
And the sectional area for outlet . } = 133 " "

A current of air rising up the tube would have its velocity reduced in the proportion of $\frac{1}{3\cdot5}$ increased to ¼ by friction (approximately), when treated as a current of air. When a tube of this character is applied to a room filled with warm air, there would not be sufficiently high velocity to cause it to rise among a volume of air possessing greater heat, and less specific gravity consequently, cold douches would fall upon the heads of those who happened to be sitting underneath or near to this inlet of fresh and cold air. The intention in this apparatus seems to be to destroy most of the velocity which the current would otherwise possess on entering the room, and it is not easy to see why such an object should have been put forward by the designer, unless, perhaps, it was from a desire to counteract some of the tendency of the ventilating arrangements in the roof to absorb all the cold air coming from the Tobin tube before it could serve the intended purpose.

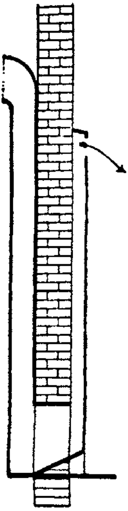

FIG. 291.

Royal Society of Arts Ventilator.—Fig. 291 represents a section of the ventilating arrangements of the Royal Society of Arts room.* This system was designed by Mr. E. C. Robins, the architect, and it occupies all the north side, and about half of the eastern side. It consists of a kind of dado, placed 5 in. in front of the wall and standing 10 ft. high—on the north side, five inlets below, led up again outside, admit air from the street, direct to the 5-inch space between the dado and the wall. Hot-water pipes are provided to warm the incoming air, quite independently of the hot-water pipes which warm the air already in the room. The inlet openings are 10 ft. above the floor, covered with a somewhat close grating 6 in. wide, and along the whole (northern) side of the room, and also along the portion of the eastern side, which latter is illustrated by Fig. 291. The grating for this portion measures 11 ft. long by 6 in. wide, of which area about one-half is closed by the grating bars. There is only one inlet grating provided for this 11 ft. long outlet, and it measures 24 in. by 12 in., with a clear area of about 200 sq. in.; inlet to room, clear area about 400 sq. in.; so the same object, rendering the velocity with which the air enters the room, seems to have been present in the mind of Mr. Robins when he designed this arrangement. What with tortuous inlets, obstructive hot-water pipes and other hindrances, the ratio between clear inlet and clear outlet must be greater than the proportion of one to two. The air will fall as shown by the arrow on Fig. 291, and that it works at all is more due to the operations of the law of diffusion of gases than to the design itself.

The Plenum System.—By the plenum system, pure and simple, fresh air is forced into the room at any convenient locality, so no stagnant places need occur; and "foul" air finds its way out by open doors, windows, or leakages; in fact, through the very openings whereon advocates of the vacuum system rely for providing their supply of fresh air! The plenum system is independent of winds and weather; and indeed each system is essentially the opposite of the other.

Combined Plenum and Vacuum System.—By the combined operation of plenum and vacuum, considerable volumes of fresh air can be forced into a room, and a corresponding quantity can be extracted by a ventilator, situated generally on the roof.

But by whatever method a supply of fresh air enters a room, there are two grand divisions in which its disposal can be arranged—

1. As a general upward flow, from

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* This room shares with the United Service Institution the unenviable reputation of being one of the draughtiest public rooms in London. (EDITOR).

floor to ceiling, or roof, and out at the top.

2. As a general downward flow, from ceiling to floor, or roof to floor, and out at the floor.

It is differences in temperature, corresponding to differences in weights, that cause gravity to give movement to air all over the globe; and, so long as the air in an assembly-room is cold, it is easy to see that the breath will ascend if directed upwards, or descend when directed downwards. As the temperature of any assembly-room rises the differences become less, and the watery vapour condenses on windows and walls, or else sinks down, and would find its own exit were it not disturbed by strong currents of air due to the patent extractor on the roof, which is often quite strong enough to interfere with the action of natural laws.

Human beings are designed so as to live a great part of their lives in buildings, or sheltered places, so the direction allotted to their expelled breath is *downwards*; but horses and other animals intended always to live in the open air, and clothed accordingly, expel the breath from their nostrils sideways, as well as downwards. Both these arrangements are hints given by nature, which we should do well to consider, for they will not lead us astray, like an incomplete theory, and we learn that the simple law that hot air rises and cold air falls, must not be accepted without reservation. Indeed, it is this law, so stated, which in matters concerning ventilation, lies at the root of the thousand and one failures we see about us. Moreover, this theory cannot account for a single example of a room or hall ventilated without draughts, due mainly to an exhauster in the roof.

For what they may be worth, "authorities" of equal importance can be quoted in favour of upward ventilation or of downward ventilation; but in this, as in all other scientific questions, it is the eternal laws of nature that we have to study and ascertain, without any servile deference to "authorities" who, after all, are only fallible human beings like ourselves.

While it is quite true that hot air ascends, because bulk for bulk it is lighter than cold air, it is also true that carbonic acid gas, discharged from the lungs, is half as heavy again as air of corresponding temperature; and the feeble force whereby air may be caused to ascend cannot prevail for long against the heavier carbonic acid gas which falls to the ground while cooling, and obviously ought to be extracted there to rest near the earth, and feed the grasses of the field.

In regard to the ventilation of buildings it is too often assumed that there is no happy medium between that of breathing air utterly foul and a system so profoundly scientific that by no chance shall any part of the air that has been once breathed enter the lungs.

The common-sense system mixes fresh air with that which has been breathed, or may be breathed again, and it does this without draughts or appreciable inconvenience, while the over-scientific system sends large volumes of cold or heated de-vitalised air into the room, and expects the forceful, irregular currents to travel in all sorts of ingenious ways that no independent currents would ever be likely to follow under any natural impulse.

The most promising foundation system for a proper and perfect ventilation is found in the Tobin tube, or Mr. Hoey's arrangement, or the plan now working at the Royal Society of Arts. But in all such examples, the minor details and general proportions are hopelessly wrong. The out-door inlet-gratings possess an area very much less than the outlets in the room, for the avowed purpose of reducing the discharge velocity into the room; consequently, much of the fresh air (which is drawn in by the suction of an exhauster in the roof) travels directly out through this exhauster; conferring but little benefit to the audience. Fortunately, however, some scattered portions of air mix by the laws of diffusion, while there are other portions which tumble out of the wire grating or mouthpiece of the apparatus, thus causing those persistent draughts for which the Tobin tube and, in a less degree, the apparatus in this room are famous.

Very little alteration would be necessary to greatly improve this apparatus; indeed, almost to make it a pattern for copying elsewhere. In the first place, a fan or other apparatus should be added, so as to regulate the amount of fresh air admitted, according to the season and the audience. As mechanical power would thus be available, the effects of contrary winds might be neglected.

Of course, the existing exhaust ventilation, and all the openings in the roof, should be closed; as the system would be converted from a vacuum into a plenum system, and from an upward-flowing current into a downward-flowing current, having for its inlet a narrow slit along the entire north, and along 11 ft. of the eastern side of the room. Entering air might, when necessary, be warmed in winter, and cooled in summer; and all vitiated air (i.e. CO_2 and water) would pass out through openings below.

A suite of rooms, erected in 1898 at the Royal Botanic Society's Gardens, Regent's-park, in London, has been provided with a system of natural ventilation, which the author considers as nearly as possible perfection, subject, however, to the one defect of being interfered with by contrary winds. This building runs almost due north and south, and advantage has been taken of the prevailing winds (which are south-west and north-east) to apply the inlet arrangements to *both* sides of the building, so that one or other can be relied upon. Of course, it would have been desirable to have a fan to make sure of a suitable current, but this could not be done, as no motive-power was available.

This suite of rooms consists of—

Entrance-Hall.—21 ft. 6 in. by 17 ft. and 18 ft. high (not specially ventilated). Heated by two radiators, each 21 in. diameter by 3 ft. high. Lighted by three Welsbach gas incandescent burners.

Drawing-Room.—22 ft. 6 in. by 26 ft. and 18 ft. high. Ventilated by three ventilators on west side only. Heated by one radiator on north side 4 ft. by 3 ft., one on east side 4 ft. by 3 ft., and one on west side 4 ft. by 2 ft. 5 in. Lighted by seven Welsbach incandescent gas burners.

Library.—22 ft. 6 in. by 17 ft. and 18 ft. high. Ventilated by two ventilators on west side only. Heated by one radiator on east side 4 ft. by 3 ft., and one on west side 4 ft. by 2 ft. 5 in. Lighted by two Welsbach incandescent gas burners.

Dining or Ball-Room.—30 ft. by 45 ft. and 18 ft. high. Ventilated by ten ventilators, five in east and five in west sides. Heated by six radiators, each 4 ft. 7½ in. long by 2 ft. 5 in. wide. Lighted by twelve Welsbach incandescent gas burners.

Café.—30 ft. by 35 ft. and 18 ft. high. Ventilated by four ventilators, two on east and two on west side. Heated by two radiators, each 4 ft. by 2 ft. 5 in. Lighted by six ordinary gas burners.

A section of the dining or ball-room is given by Fig. 292; and a section of one ventilator to a large scale is shown by Fig. 293. The room is 18 ft. high from floor to ceiling, and the roof is hermetically sealed, having no openings whatever. No special provision is made for the exit of CO_2 from below, as the doors and usual cracks and crannies are found to be sufficient.

The room is lighted by twelve Welsbach incandescent gas burners, so there is a considerable amount of heat to be disposed of. Fresh air is admitted by ten inlets, five being on each side. These are set at about equal intervals apart along the room, and 2 ft. below the springing of the roof, or ceiling.

Each inlet grating is provided with a sliding shutter, whereby the area open can be regulated. Although the "air bricks" measure 11 in. by 16 in. outside, the clear area is but 30 sq. in. for each ventilator. The inlets to the room measure 16 in. × 3 in. = 48 sq. in., or one-third of a square foot, and when tested by an anemometer, the current varied considerably, generally reaching a speed of 300 ft. per minute and sometimes the current reversed. The results of these arrangements have been quite satisfactory, there is a complete absence of draughts, and of those cold douches of Arctic temperature which make so many assembly-rooms in town or country models of discomfort and veritable death-traps. Most of such rooms are decorated with a lavish generosity, while no care whatever is given to ventilation, scientific or otherwise. Such rooms are contentedly supplied with a big hot-air extractor in the roof, which creates all the draughts below, and the whole barbarous arrangements takes a toll of human life which it is perfectly appalling to contemplate.

It would be impossible within the limited time allotted to any one paper, to enter into all the aspects of efficient ventilation, for each case must be separately considered. It is more of an engineer's than an architect's work to provide proper ventilating arrangements, and several points may be expressed, in conclusion, giving the author's views upon this important subject.

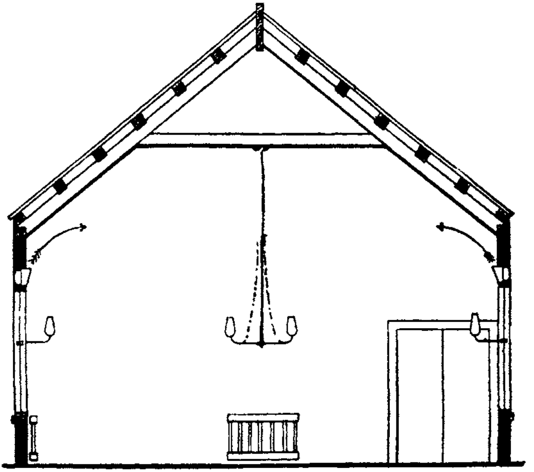

FIG. 292.

1. Ventilation should, as far as possible, be carried out by the plenum, and not by the vacuum system.
2. Fresh air should be introduced as an upward current from openings above the heads of an audience, but not so high as the ceiling. It should be driven in divided streams into the upper part of the room, so as to mix with warm air already travelling there.

3. Exits for carbonic acid, dust, and watery vapour should be provided at or near to the floor level, if required.

4. The roof or ceiling of a properly ventilated chamber should be hermetically closed.

5. Open windows should only be used during warm weather, never in winter.

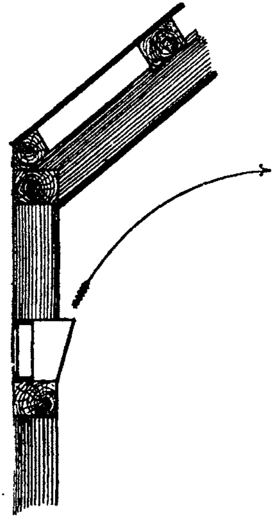

FIG. 293.

6. As natural draughts cannot always be relied upon, fans, or a furnace, or other means of producing artificial draughts should be resorted to—when necessary.

Local convenience, surrounding buildings, and sources of pure air are bound to require many modifications in arrangements, and the general principles advocated in the present paper are capable of an almost infinite variety in application.

Volume of Air Required per Person in Rooms.—In the relative sizes of air ducts, etc., given further on, the comparative areas for the inlet and ventilating shafts are included, and for residence work this may be worked to without considering the number of people that may be occasionally gathered in a room. When, however, the work is in public places, institutions, schools, etc., it is necessary to consider the number of occupants, and furnish a supply of new air and remove a volume of vitiated air that amounts to so much per head. Referring again to residence work, or the like, there are usually brick-built chimneys to all the principal rooms in a house, and these serve excellently as extract ventilating shafts, assuming they have a normal up-draught in them. If, however, a house or place was built expressly to be warmed by heated air, and chimneys were dispensed with, then ventilating shafts would have to be provided as a detail in the building construction, and the rule that is given a little later on should be worked to. Ordinary chimneys may be said never to err on the side of being too small to ventilate any room in a residence, and it is only when ducts for the vitiated air have to be made or built expressly that their size must be calculated.

When the extraction of cooled and vitiated air and the supply of new warmed air has to be calculated at per head, then the two following tables must be worked to:—

CUSTOMARY VOLUMES OF AIR ALLOWED PER PERSON IN INSTITUTIONS AND PUBLIC PLACES.

	Cubic feet per minute.
Schools, infants	28 to 30
,, scholars of full size	30 ,, 32
,, dormitories . .	25 ,, 28
Workrooms, slight exertion, air not vitiated by the trade followed . . .	35 ,, 40
,, full exertion .	45 ,, 50
Public halls, meeting rooms	35
Ball rooms	45
Theatres, dining halls . .	35
Hospitals, ordinary wards and rooms	45

VOLUME OF AIR, IN CUBIC FEET, EXTRACTED PER MINUTE BY A VENTILATING SHAFT OF ONE SQUARE FOOT AREA.

No allowance made for friction; deduct 35 to 50 per cent. for this, according to height and size of shaft.

Height of Ventilating Shaft in Feet.	Excess of Temperature of Air entering the Ventilating Shaft, above the External Air					
	5°	10°	15°	20°	25°	30°
10	116	164	200	235	260	284
15	142	202	245	284	318	348
20	164	232	285	330	368	404
25	184	260	318	368	410	450
30	201	284	347	403	450	493
35	218	306	376	436	486	531
40	235	329	403	465	518	570
45	248	348	427	493	551	605
50	260	367	450	518	579	635

It is requisite to mention that a ventilating shaft must have the same consideration as a smoke flue in regard to its upper termination. Although the table may show that a short shaft will meet the requirements, still it must go to the top of the building and up above its highest ridge. If not, it will suffer with down-blow or retarded up-draught (when certain winds are blowing), the same as a fireplace chimney. A ventilating shaft must be considered as a chimney in regard to its height and the conditions which ensure its having a permanent up-draught of regular speed.

If these shafts are built in brickwork during the construction of the building, they may be carried up separately and terminate either singly or in stacks as brick chimneys do, but if a hot-air apparatus is installed in an existing building and the heating engineer has to provide metal ventilating shafts, then it is the custom to connect several, or all of them, into one main shaft (which usually runs along or through the attic or roof space) and carry this up and out like a chimney. It would not be possible, nor sightly, to carry a number of single metal tubes up through a roof. In certain necessary cases a gas ring is put in the base of the main shaft to stimulate the draught, or a mechanically driven air propeller.

Rules for Calculating Sizes of Cold and Warm Air Ducts, Registers and Ventilating Shafts.—Residence or similar work only, in which each person has about 400 cub. ft. of space. For institutions see previous table.

Heaters, 8 to 9 sq. ft. of heating surface per 1000 cub. ft. of space in the rooms to be warmed.

This allows for a low temperature heating surface. Warm-air ducts to ground floor, 50 sq. in. area per 1000 cub. ft. of space in the rooms to be warmed.

Ditto, ditto, first floor, 40 sq. in.

Ditto, ditto, second floor, 32 sq. in.

Cold-air duct to stove chamber, three-fourths the total area of the warm-air ducts.

Grating to cold-air duct, if lined with wire gauze, double the area of the duct.

Registers or gratings in rooms, through which the warm air is delivered, one-fourth greater area than the warm-air ducts which serve them. This ensures the gentle delivery of 3 ft. to 4 ft. of air per second, and causing it to spread out as it enters. The area of a register grating is that of the open spaces in it. The metal portion averages one-fourth to one-third, the latter most usually.

Extract ventilating shafts or ducts, which carry off the cooled and vitiated air, ground floor 32 sq. in. area per 1000 cub. ft of space in the room.

Ditto, ditto, first floor, 40 sq. in.

Ditto, ditto, second floor, 50 sq. in.

Registers or gratings of ventilating shafts, the same area as the shaft, but this area must be that of the open spaces of the grating. The metal portion averages one-fourth to one-third, the latter most usually.

Areas of round pipes (for cellars) can be ascertained by deducting one-fifth of the area if square; thus an 8 × 8 in. square pipe has 64 sq. in., while a round pipe of 8 in. diameter would have nearly 51 sq. in.

The following is a simple rapid table for round pipe:

Diameter of Round Pipe.	Will Serve a Ground Floor Room.	Will Serve a First Floor Room.
in.	ft.	ft.
8	10×11	12×12
9	12×12	12×15
10	12×14	14×17
11	14×16	16×18
12	15×18	18×20

A 7-inch pipe may be used for cloak rooms, small bath rooms, etc.

There now remains to be described a means of arranging for a hot-air apparatus to either heat a continuous stream of new air (as already described) or to partially or wholly heat and reheat the air already existing in a place. In schools, places of worship, public halls, and the like, which have to be warmed some time before they are occupied, there is effected an economy in fuel and, particularly, an economy in time, if the apparatus is first devoted to heating the air contained in the place without heating a stream of new cold air all the time. It will be seen that there is no occasion for a full and constant change of air when the place is unoccupied, and the trouble experienced in all public places which have to be heated up each time they are required for use is the long time taken in getting the required warmth. Again, there are places which have a varying number of occupants, and if the ventilating arrangements are suited for the maximum number, there is no reason why this should not be checked and the contained air partially re-heated when the number of occupants is much below the maximum. This economises fuel and labour.

In some experiments carried out to ascertain the best and worst points at which registers might be fixed, which were conducted in a small room—a model schoolroom—the warmed air was made visible by smoke. The best results were obtained with the registers both on one side of the room, as just recommended. Air introduced at a greater velocity than usual might alter these results, but in warm-air work the velocity should never exceed 5 cub. ft. per second, while 3 ft. to 4 ft. is decidedly better, as already stated.

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VINEGARS.

(*a*) To 1½ bushel of malt add 10 gal. of water at 170° F. (or closely thereabouts), stir for half an hour, then strain off the clear liquid. Put another 10 gal. of water to the malt and proceed as with the last. Lastly, put 5 gal. of water to the malt and treat this the same. This quantity of water will then have exhausted the malt. Mix the 25 gal. of liquor and cool as quickly as possible to 70° F. Add yeast, stirred in, and cover the pan. Allow to ferment for 30 to 36 hours, then carefully strain off the wort and fill it into casks. These must not be filled more three-quarters full. The casks are set on their sides, as a 2-in. hole (or several smaller holes) must be bored in each end (above the line of the liquor) to allow air to enter freely. Let the casks be put in a cool, airy place for the acetification to take place. The latter will take from four to six months, and on completion the liquor, now vinegar, is filtered. This is a slow process, but yields a good result. A quick process is as follows.

(*b*) Take a sound cask or barrel and prepare it as follows. Put a false bottom in, this bottom to be bored with holes. On this perforated bottom put hard wood shavings, preferably beech. Near the top insert another perforated partition, but in the perforations of this one fit short lengths of glass tube to stand up about an inch above, and in these tubes put some cotton wicking so that liquid will only pass through slowly, drop by drop. A tube to discharge the vinegar automatically, it being a siphon, will act each time the vinegar rises (in the cask) as high as its neck. Around the space between the false bottom several holes are bored to admit air. These holes must, of course, be above the neck of the siphon. The shavings should be boiled previous to putting them in the cask, or they may be put in the cask first and boiling water poured through until it comes away clear and colourless. The process is started by running some hot vinegar through (if the vinegar is in process of fermentation, so much the better), this being to inoculate the shavings with the vinegar ferment. When this is done the whole is allowed to stand several days, say a week, and then fermented wort (see preceding recipe) is poured in on the top division and allowed to trickle through slowly. When it is through it is put back to pass through again two or three times until it has the characteristic odour of vinegar. This may sound a deal of trouble, but it only amounts to preparing the vinegar plant, for after this, when the plant or ferment (a fungus, really) has started to grow on the shavings, vinegar can be produced by passing the wort through once only, if in a warm room. Diluted beer can be used for making vinegar, or sugar solution will serve if it is previously fermented with yeast, for about thirty hours, in an open tub. The finished vinegar can be filtered through filter-paper, put in a funnel; or white blotting-paper can be made to serve.

(*c*) Take 6 lb. ground malt, 6 lb. crystallised raisins, 4 lb. treacle, ½ lb. cream of tartar. Pour on these 8 gal. of boiling water and leave all to mash for 6 or 8 hours, stirring well as usual. Run off the liquid into another tub and add ¼ lb. sulphuric acid and 24 gal. of acetic acid. Colour with caramel (burnt sugar) and rack into a cask. Allow to settle for three days, and then draw off the clear vinegar and it is ready for use.

To make Vinegar from the Vinegar "Plant" or "Mother."—The vinegar plant can be readily purchased at large vegetable markets, or through a local tradesman. Take 1 qt. of water, and dissolve in it ½ lb. of coarse brown sugar and ½ lb. of treacle. Let this be in an earthenware vessel, preferably white inside. When dissolved, lay the fungus on top, cover with thick brown paper, and tie down. In six weeks. or a little longer in cold weather, the liquid is turned to vinegar, and can then be strained off. Boil up the vinegar, strain again, if necessary, then bottle. Put the fungus on to more sugar, treacle and water, to keep it going; by this means it will not only keep alive but will grow thick, so that it can be divided into two layers, and thus becomes two plants. It appears to improve in its work as it grows thicker.

Tarragon Vinegar.—The full-grown shoots of tarragon are used for this, and they should be gathered the day before they are needed. Fill a half-gallon jar with as many as will go in without pressing down. Add three cloves, and the rind of one lemon, cut thinly. Fill up the jar with white wine vinegar, and tightly cork it. Expose to the sun for two or three weeks, then open and strain off the vinegar. Wring the tarragon in a cloth, filter all the vinegar through flannel, then bottle it.

Cucumber Vinegar.—For salads, or as a cold meat sauce. Peel three moderate-sized cucumbers, and slice them. Put them into a jar, and pour on a quart of cold vinegar. Slice two onions and two shallots, and add these, together with a tablespoonful of pepper, a quarter-tablespoonful of cayenne and about a tablespoonful of salt. Let this stand for a week. At the expiration of this time boil all up, then allow to get cold. Strain through flannel, then bottle.

Garlic, or Shallot, or Horse-radish Vinegar is simply made by putting 2 oz. of finely chopped garlic, or shallot, or scraped horse-radish, into a quart of cold boiled vinegar, and, after it has infused for about two weeks, the vinegar is strained off and bottled. With horse-radish vinegar a little finely-chopped shallot is an improvement. Either can be used as soon as made.

Raspberry Vinegar.—Take 3 lb. of fresh raspberries, and put 1 lb. of them into a bowl. Pour a pint of best vinegar over, bruise the raspberries, and let it remain until next day. Strain off the vinegar, and pour it over another pound of the raspberries. Bruise the fruit, and let it remain another day. On the next day drain off the vinegar again, and pour it on to the third pound of raspberries. Bruise the fruit, and let it stand another twenty-four hours. Now drain off the liquor for the last time, and strain it through flannel which has been previously wetted with plain vinegar. When draining off the vinegar at any time do not press the fruit, for should too much fruit juice, or any pulp, pass through, the finished vinegar will ferment. Indeed, some consider that the fruit should not be bruised at all, for fear of fermentation; but if care is used the bruising can be done, and a fuller flavoured vinegar is obtained. When the vinegar is passed through flannel, put it into a jar, and add 1 lb. of loaf or castor sugar to each pint. When the sugar is melted, put the jar into a saucepan of boiling water, let it simmer for half an hour, remove the scum, then allow to get cool. When cold put into bottles, cork well, and wax over the corks. If liked, a quarter-gill of brandy can be added to each pint just before bottling.

Aromatic Vinegar.—16 oz. glacial acetic acid, 40 drops oil of cloves, 40 drops oil of rosemary, 40 drops oil of bergamot, 16 drops oil of neroli, 30 drops oil of lavender, 1 drachm benzoic acid, ½ oz. camphor, 30 or 40 drops compound tincture of lavender, 3 oz. spirits of wine. Dissolve oils, benzoic acid, and camphor in the spirits of wine, mix with acetic acid and shake until bright, lastly adding tincture of lavender to colour.

Testing Strength of Vinegar.—This is usually done by the neutralisation process, the acidity being neutralised by a solution of caustic soda of a known strength. The soda solution should be prepared by a chemist, and is known as a normal solution, containing 40 gr. of pure caustic soda to 1 litre. Some of the vinegar, say 20 c.c., is put into a glass, and a few drops of the alcoholic solution of the indicator phenolphthalein added; the soda solution is then added, a drop at a time, from a burette, the glass containing the solution being shaken all the time. Immediately the soda becomes in excess a deep pink colour will appear, and directly this occurs the addition of the soda solution must cease. Now see how much soda solution has been used and calculate thus: 1 c.c. of soda solution (which carries 0·01 gr. of NaHO), is equal to 0·06 gr. of acetic acid, therefore if. for example, 21 c.c. of the soda solution has been used to the 20 c.c. of vinegar, the acetic acid in 100 pints of vinegar is 6·3 per cent. The usual percentage is 4·5 to 5 per cent., this being governed by the strength of the mash employed in making it.

Aromatic Vinegar.—A delightful aromatic vinegar may be concocted with herbs as a basis. This vinegar is a most useful and eminently satisfactory preparation. It has remedial properties, and, therefore, is invaluable in the sick-room; the rich, spicy odour produces a sense of coolness that is at once a tonic; it also performs its mission as a deodorizer by virtue of its essential oils.

The ingredients to be used are 8 oz. each of sweet basil, thyme, and spearmint (*mentha viridis*), 6 oz. each of rosemary, rue, lavender, and sage. Place in a stone jar and bruise the leaves (many aromatics, when entire, are odourless, and only give off their fragrance when bruised), cover with 2 gal. of strong vinegar, made boiling hot, and cover closely; set in a warm place, shaking the jar occasionally. At the end of two weeks strain off the clear liquid. Cover 1 oz. of gum camphor and 2 oz. of gum benzoin with half a pint of alcohol and allow to dissolve; then add to the vinegar. Let stand a few days, filter, and bottle in small bottles, with cork and seal. Keep for two months before using; it improves with age. A tablespoonful to a quart of water makes a refreshing wash for the skin; it is an excellent sedative for the flesh, rendering it smooth and firm, and it is said to be a defence against wrinkles.

* * *

WALKING-STICKS.

See also POLISHING, STAINING, VARNISHING, ETC.

(1) ALTHOUGH the walking-stick is not now so largely used as in years gone by, yet the demand for sticks for umbrellas and sunshades has been on the increase, and for these latter fancy goods there is a constant seeking after novelties to either meet a fashion or create new desires. There is, therefore, a keen look-out being kept up for new materials, particularly those that may be classed as "novelties." So great is the demand in this respect that many growers, particularly on the Continent, have taken up the cultivation of sticks of various good kinds expressly to supply the stick market. In this country, land is generally of too high a value for it to be placed under such a system of culture, though quite recently large quantities of ash saplings, in which the roots have all been directed in one way to form what is known as cross-heads, have been grown in the county of Surrey.

Some years ago the first collection ever got together illustrating the material used for walking-sticks was presented to the museum of the Royal Gardens, Kew; and this collection has been entirely revised and augmented by the same firm which originally presented it, namely, Henry Howell and Co., of Old Street, St. Luke's.

Forest produce from all parts of the world is here deposited. From the East and West Indies, Singapore, Java, China, and other eastern countries, are derived a great variety of sticks, principally, however, belonging to the bamboo and palm tribes. The sticks, as required for the workshops, are drafted from the stores. Some are so crooked that they require a great deal of straightening before anything else is done with them, and this straightening process is one of the most interesting and remarkable. On the top of a very hot stove is a heap of damp sand, in which the sticks are plunged, and kept there till they have become quite pliable. The workman then takes the crooked stick while it is still hot and inserts it into a notch cut in a stout board, placed at an angle inclined from him, and bends and strains it, occasionally casting his eye along it to see that it is straight, and when perfectly so it is thrown down to cool, and when cold it is quite rigid, without the slightest fear of it ever going back to its natural crookedness. In this way some of the most irregular and apparently worthless sticks are made to assume an appearance almost impossible, when we consider that the workman has nothing but practice and a well trained eye to guide him. Heat is a very important element in the manipulations of a stick-maker, and produces very different effects on the several kinds of woods, the degree of heat necessary to straighten one kind of stick being often sufficient to completely spoil another kind. The same power which makes a crooked stick straight is applied to make a straight one crooked, and so we find that the rigid stems of bamboos, partridge canes, and all the various kinds of English sticks which are required to be curled or twisted, are by the application of heat made to assume almost any shape or form. Thus, ladies' sunshade handles, especially those of bamboo or partridge cane, can be twisted and even tied into double knots.

By far the largest number of sticks used are those known as natural sticks, that is, saplings of trees or climbing plants, where the roots have sufficient character to form handles, or knots. These are always more in demand, whether for walking, umbrella, or sunshade sticks, than those that are cut from the solid, like letterwood, ebony, boxwood, beef-wood, partridge-wood, etc. Messrs. Howell, with the view of bringing to light undeveloped resources, have had some notes drawn up and circulated among their correspondents, on the points to be observed in collecting raw sticks, canes,* etc., for walking sticks, umbrella handles, etc. The total length should not be less than 42 in., end to end, and if possible they should be 48 in. The best sizes are of the diameter of ½–1 in., measured about midway; they should not be larger than 1¼ in. It is indispensable that the diameter should gradually diminish from the root, or handle, to the point, so that the stick is not "top-heavy." It is always better, when possible, to send sticks with some kind of handle; if the plant be pulled up, the roots should be left quite rough and untrimmed; if a branch be cut off, a part of the parent branch should be left on to form a knob or crutch handle. Sticks without handles can be used, especially if they are nicely grown and have any peculiarity of structure or colour; but if there is any handle, however small, it should not be cut off. Young saplings of the different kinds of palms, bamboos, etc., should always have the root left on. Occasionally the form of the root or handle part is attractive, while the stick itself is weak and defective; in such cases the handles only should be sent, and they should measure 15–18 in. long. In sending specimens of new sticks, it is better to send only small quantities, say one or two dozen, at most of each kind, then, if approved, further quantities can be asked for. Specimens of anything remarkable for form or colour, whether in the roots or stems of woody, herbaceous, or reedy structures, should be sent, as sometimes the most unlikely things are found to possess value for use either as umbrella handles or walking-sticks.

It will be seen from these notes that, as before stated, the chief demand is for natural sticks, many of which lend themselves readily to the varied designs so necessary for ladies' sunshades. Not many years since the whole of the machinery in use was worked by hand, but in consequence of it being necessary to turn out very large orders with great rapidity, steam power was introduced, which sets in motion band and circular saws, planes and rasps, with the result that a stick of the toughest description can be converted into a marketable article in a very short time. So dexterous do the workmen become in the use of these tools that they seldom make even the slightest error in their work, and the rapidity with which the workers in gold and silver mounting perform their delicate manipulations is remarkable. Besides the precious metals, a great variety of valuable stone mounting is effected in this department, among the stones used being Mexican onyx, agate, jasper, various marbles, and occasionally even the more precious stones, including diamonds. Ivory, horns of all kinds, rhinoceros, buffalo, stag, sea-horse, walrus tusks, etc., are also largely used.

Material.—In enumerating the materials used in the manufacture of walking-sticks it has been thought best to classify them in alphabetical order according to their commercial names. Though the following is a fairly complete list, and represents most of those exhibited in the Kew Museum, it is by no means an exhaustive list, additions being frequently made.

Acacia.—The name of this stick designates its peculiar colouring rather than its botanical origin, and any stick that is sufficiently strong, and lends itself readily to artificial colouring, is used, such as crab, dogwood, etc.; the specimens at Kew are the produce of a hard-wooded shrub or small tree, found in the forests of Middle and Southern Europe, probably belonging to the dogwood order. The sticks, in their prepared form, have found much favour for ladies' umbrella and sunshade handles. They are made in various shapes, but the colour is generally bluish or greyish, with a metallic lustre, and occasional dark streaks.

Apse or Asp.—This is the wood of the aspen (*Populus tremula*); it is very light both in colour and weight, and has little else, perhaps, to recommend it for walking sticks. The supply is obtained from our own country.

Ash (*Fraxinus excelsior*).—This tree furnishes a variety of sticks, known in trade under different names, as, for instance, the root ash, which consists of the saplings with the roots attached, which form the handle; then there is the cross-head, in which the roots, instead of forming a somewhat globular knob, take a twist at right angles from the stem. These have been grown, and so directed during their growth. The figured ash is another form, in which the bark has been scarified into various designs during growth, and on healing has left a permanent marking. These latter are, perhaps, more curious than beautiful, but still they have their admirers. The ash can be treated in various ways with the bark either left on or removed. Some of those with the bark remaining, when properly cleaned, dressed, and polished, make very pretty sticks, and are not unlike those of the orange.

Bakow.—This is apparently the produce of a palm, but at present its origin remains unknown. The sticks are imported from Singapore.

Bamboo.—The bamboos furnish a great variety, and a very large bulk of the material used by the walking-stick maker. They come, of course, chiefly from the East, but their botanical sources are difficult to determine. Amongst those which may be called true bamboos, namely, those furnished by the genus *Bambusa*, may be mentioned the Whampoa bamboo, probably the produce of *Bambusa metake*. They are noted for their irregular jointing; they are of a clean, lemon-yellow colour, and not long since were much used for sunshade handles. They are imported from China. The yellow bamboo and the black bamboo are also well-known, their colours being indicated by their commercial names. These canes are imported from Japan and China, and are no doubt the produce of species of *Bambusa*, as is also probably the beetle-cane, so named from its intensely black colour and its scaly appearance near the root, which, however, makes it very pretty. This is also the product of a Chinese species. The dog-head bamboo is not a true bamboo, but is furnished by a species of *Arundinaria*, a closely-allied genus. The name dog-head has been given to this stick from the natural growth of the rhizome roughly representing the head of a dog, so that it is easily carved and converted into good representations of dogs' heads. These sticks are imported from China.

Bay Tree or Laurier Thyn.—These sticks are apparently the produce of a species of *Eugenia*, though nothing definite is known about them. The wood is very hard and close-grained, almost white in colour, but with a cinnamon brown bark covering the irregular root, which makes good handles for umbrellas. They are imported from Algeria.

Beef-Wood.—This wood is of a dull reddish colour, close and even grained. It is apparently cut from the trunk of a large tree, perhaps that of *Ardisia coriacea*. It is imported from Cuba.

Beetle Cane.—See Bamboo.

Birch.—The saplings of *Betula alba*. The roots make good handles, and the supply is obtained from our own country.

Blackthorn.—This well-known hedge plant, known also as the sloe (*Prunus spinosa*), makes excellent walking sticks. There is always a demand for them, for when properly dressed and polished there is no other stick that has so dark a coloured bark. Latterly there has been a large sale for a special kind of blackthorn brought from Ireland, and known as Irish blackthorns. They are distinct from the ordinary blackthorn in being flattened instead of cylindrical.

Black Tork.—The botanical origin of this stick has not been determined. It has a dark-coloured bark, and the root forms an irregular knotted handle. The wood, which is hard and close-grained, forms a very rigid stick, revealing, when the bark is taken off, a dark brown wood with occasional light patches. It is imported from the West Indies.

Boxwood, Persian.—This is the true box (*Buxus sempervirens*), the wood of which is so well known as to need no description. The irregularity of the branches recommends it, when peeled of its bark, for walking sticks, and the sticks cut out of the solid trunk make good umbrella sticks, besides which it is often carved into various devices for ladies' sunshades. Another kind of wood, very similar in appearance to true box, but known as West Indian boxwood, is used to some extent for the same purposes. The West Indian boxwood of botanists is *Vitex umbrosa*, but this wood does not agree with that, and at present cannot be satisfactorily identified.

Briar.—This is also the produce of a West Indian tree (*Zanthoxylum Clava-Herculis*), the bark of which is tuberculated, or warted, for which reason it is valued for walking-sticks. They are imported from the West Indies.

Cabbage, Jersey. — A well-known variety of the common garden cabbage (*Brassica oleracea*), the stems of which grow in the Channel Islands to a height of 10 or 12 ft.

Carob or Caroubier (*Ceratonia Siliqua*).—A branching tree about 30 ft. high, native of the Mediterranean coast. The knotted and irregular branches, when straightened, make excellent walking sticks. They are imported from Algeria.

Carolina Reeds.—These are slender, bamboo-like canes, the produce, apparently, of a species of *Arundinaria*. They are imported from China.

Cedar-Wood.—This is the wood of the common pencil cedar (*Juniperus virginiana*). It is only occasionally used, and is too well-known to need description. It is imported from North America.

Cherry (*Prunus cerasus*).—Of late years this has become a very important stick, both for walking sticks and sunshade handles. Two distinct forms of the cherry are known in the stick trade—namely the scented and the tiger cherry. The former has a dark brown bark, which has a peculiarly sweet scent, and, in consequence, is seldom or never polished, the effect of which would, of course, be to kill the perfume. The tiger cherry has a bark with patches of a beautiful golden lustre, which is heightened by the addition of polish. These sticks are imported in large quantities from Austria and Hungary, where the growth for pipes and walking sticks constitutes a staple industry.

Chestnut.—These are branches or saplings of the Spanish Chestnut (*Castanea sativa*). When peeled the wood is of a very light colour, but is hard and durable. The sticks are obtained principally from France.

Coffee.—These sticks are the produce of the ordinary or Arabian coffee-tree (*Coffea arabica*), and are brought here from the West Indies. They are very hard and heavy, with a light-coloured bark, and have but little to recommend them.

Cork.—The produce of the cork oak (*Quercus Suber*). Though these sticks are somewhat clumsy in appearance, owing to the thick and rugged deposit of bark or cork, they are light in weight from the same reason. They are imported from Spain and Algeria.

Crab.—Two kinds of stick are furnished by this plant—the wild form of the cultivated apple (*Pyrus malus*), the plainer sticks being known as crab, and the knotted or irregular sticks as warted crab. They are the produce of our own country, though some are imported from the Continent.

Date Palm.—These are the mid-ribs of the leaves of this well-known palm (*Phœnix dactilifera*) with the leaflets cut off, rounded and smoothed, and then polished. They are imported from Algeria.

Dogwood (*Cornus sanguinea*).—This is a well-known shrub of our own hedges, the wood of which is hard and not liable to splinter; hence it was at one time much used for butchers' skewers. These properties, together with those of rigidity and lightness, have caused the sticks to become very much in favour with walking-stick makers. On this account they are much used for the "pillars" or sticks of umbrellas or sunshades, often having other handles or knobs fixed to them. They are imported in large quantities from France, Germany, and other parts of the Continent.

Ebony.—Several kinds of ebony are known in the trade as Ceylon, Macassar, and flowered ebony. The two former are the produce of *Diospyros ebenum*, and the latter of a totally different plant, namely, *Brya ebenus*. The first is a native of Ceylon and India, and furnishes the best true ebony, while the second is a small tree native of the West Indies, and is sometimes known as green ebony and cocus-wood, so much used for making flutes. The ebonies furnish very choice sticks, which are cut from the solid wood.

Eucalyptus.—This, as its name implies, is the produce of *Eucalyptus Globulus*, better known, perhaps, as the blue gum. It is a native of Australia, but has been introduced into many other parts of the world. The supply for the stick trade comes from Algeria.

Fullers' Teazle (*Dipsacus Fullonum*). This plant is probably only a cultivated variety of the common teazle found wild in our copses and hedges (*Dipsacus sylvestris*). The plant is cultivated in some parts of this country, as well as in France and Germany, for the sake of the hooked bracts of the flower-heads, which are used for teasing or carding cloth. The adaptation of the stems for sunshade handles is very singular, for most of those used for the purpose are fasciated or abnormally twisted in the process of growth, so that they become double or treble their normal size. This fasciation was at one time considered to be unusual in the teazle, and their appearance a few years since in thousands as sunshade handles came as a surprise to the botanist. It exemplified, however, what has been before said, how apparently useless products can be made subservient to the demands of commerce. Teazle stems are imported from France.

Furze, sometimes also known as Whin or Gorse (*Ulex europeus*).—The stems of this common British plant are, as is well known, very irregular in their growth. When they are straightened and properly dressed, however, they make extremely pretty walking and umbrella sticks, and are in great demand.

Gru-Gru.—These are the saplings of a palm, the botanical origin of which cannot be accurately determined, inasmuch as the name gru-gru is equally applied to *Astrocaryum vulgare* and *Acrocomia sclerocarpa*, both South American species. The sticks are very beautiful, being of a rich dark brown with fine white longitudinal lines near the joints. The rootheads also are very handsome. The sticks are imported from the West Indies.

Guelder Rose (*Viburnum Opulus*).—The sticks from this well-known shrub are very attractive when dressed and polished. The bark which covers them is of a rich brown, thickly marked with white lines. They are of a comparatively recent introduction, and are very much in demand. They are sometimes known under the name of Balkan rose, being imported from the neighbourhood of the Balkans.

Hazel.—This well-known stick is the produce of *Corylus Avellana*. A variety known as silver bark hazel is the most beautiful. The sticks are imported from various places on the continent of Europe.

Holly (*Ilex aquifolium*).—The sticks of this favourite shrub are so much used for walking-sticks, whip-handles, and similar uses that they need only to be enumerated. They are chiefly the produce of our own country.

Hornbeam (*Carpinus Betulus*).—A well-known hard-wooded tree; the wood is of a very light colour, but makes durable sticks. The market is supplied by English growth.

Jambee, or Jamboze.—This is apparently the produce of the palm, which has yet to be determined.

Lancewood.—This wood, supposed to be the produce of *Duguetia quitarensis*, a tree of South America, is much used for shafts of carriages, whip-handles, and the top joints of fishing-rods, in consequence of its elasticity and strength. For the same reason it is used for walking- and umbrella-sticks.

Loya Canes.—The stems of an Australian palm (*Calamus australis*). They have somewhat the appearance of a rattan, to which they are a close botanical ally.

Malacca (*Calamus scipionum*).—Like the last, these are the stems of a climbing palm, imported, not from Malacca, but from Siak, on the opposite coast of Sumatra. They are a very choice stick, and fetch perhaps the highest price of any stick in the market.

Maple (*Acer campestre*). — The branches of this well-known British tree are sometimes used for walking sticks, as well as the wood of its American ally, the bird's eye maple (*Acer saccharinum*).

Medlar (*Pyrus germanica*).—Sticks of this plant are imported from France. They are sometimes covered with numerous transverse gashes, which is done in the stem during growth for the purpose of ornamentation.

Midgen.—This is the stem of an Australian palm (*Kentia monostachya*). It makes a very pretty stick, from the markings or scars of the fallen leaves being very close together,

Mountain Ash.—A well-known ornamental tree of our shrubberies (*Pyrus Aucuparia*). The sticks are slender but strong.

Mountain Bay.—A slender palm, the source of which is unknown.

Myall Wood (*Acacia homalophylla*).—A leguminous tree of Australia, the violet-scented wood of which is well known and has been much used of late in the manufacture of pipes. The sticks are not polished, so as to preserve the scent.

Myrtle.—Whether this is the produce of the *Myrtus communis* is somewhat doubtful. It makes excellent walking and umbrella sticks, which are imported from Algeria.

Nana Canes.—This name has been given to the hollow reed-like stems of *Arundo donax*, the rhizomes of which form excellent handles for umbrellas and sunshades. They are imported from Algeria.

Oak (*Quercus Robur*).—The saplings and branches of this well known British tree are much used for walking-sticks, and are always in favour. Under the name of Brazilian oak, a stick that has met with a very large demand has been known in the market for some few years. It is corrugated longitudinally and knotted throughout, the knots being especially thick near the knob. Though this stick is a great favourite, its botanical origin at present is obscure. It is imported from Bahia, and is sometimes known as the Ceylon vine.

Olive (*Olea europea*).—This is another favourite stick for which there is always a large demand; the dark green bark has a character of its own, and the brown marking of the wood, when stripped of its bark, has much to recommend it. Olive sticks are imported chiefly from Algeria.

Orange.—The orange sticks, which are imported chiefly from Algeria, are probably the produce of other allied species besides that of the common orange (*Citrus aurantium*). The bark of the orange, when dressed and polished, has a bright, greenish colour, with white streaks, and makes extremely pretty sticks, for which there is a constant demand.

Orange, Black.—This is a distinct product from the foregoing, and is not furnished by any species of *Citrus*, but by the common broom (*Cytisus scoparius*). The bark has somewhat of the orange marking, but its colour is nearly black, as its trade name indicates. It is imported from Algeria.

Palmyra.—These sticks are cut from the solid wood of the palmyra palm of India (*Borassus flabelliformis*). Two varieties are known, black and red, the one with intense black lines, the other with red. The wood is imported from India.

Partridge Canes.—Under this name an immense quantity of canes, with and without the bark, are annually imported from China. Though they are a specially favourite stick for walking, umbrellas, and sunshades, the botanical source still remains unknown. They are largely used for twisted and curled handles.

Partridge Wood (*Andira inermis*).—This is a large tree of the West Indies. The wood is close-grained and hard, and takes a good polish; it is used chiefly for umbrella handles.

Penang Lawyer (*Licuala acutifida*). This is a palm, the saplings of which, with the roots attached, are imported in considerable quantities from Penang.

Pimento (*Pimenta officinalis*).—A tree common in Jamaica, where it is largely cultivated for the sake of its fruits, which are the allspice of commerce. For the stick and umbrella trade large quantities of the young saplings are imported from the West Indies. The sticks are valued especially for umbrella handles, in consequence of their rigidity and non-liability to warp.

Pomegranate (*Punica Granatum*).—These sticks come mostly from Algeria, where they are specially cultivated.

Rajah Cane.—This favourite stick has been known in commerce for some 20 years or more. It is imported from Borneo, and for a long time after its introduction its botanical origin remained a mystery. It has, however, since been referred to the genus of palms *Eugeissonia*, and probably to the species *minor*. The commercial name rajah is said to be derived from the fact of the duties paid for its export being claimed by the Rajah of Borneo.

Rattan.—Under this name a variety of sticks, apparently the produce of different species of *Calamus*, are known. Thus we have root rattans, white hard-barked rattans, monster rattans, miniature rattans, and so on. They are all of a similar character, with the scars of the fallen leaves strongly marked in transverse rings. They are the produce of Eastern countries.

Snakewood (*Brosimum Aubletii*).—This is also known under the name of letter-wood and leopard-wood. It is the produce of a large tree, native of Guiana, Northern Peru, Brazil, and Trinidad. The wood is extremely hard, of a reddish-brown colour, marked with dark transverse blotches. It makes one of the handsomest sticks known, and when mounted with gold has a very rich appearance.

Thistle.—Under this name the stems of the mullein (*Verbascum Thapsus*) are known in commerce. They are slender and very light, both in colour and weight; they are, however, very prettily marked, and make good handles for umbrellas.

Tonquin Canes.—These are slender-jointed sticks of the character of bamboos, and are the produce of an unknown species of *Arundinaria*. They make light and strong sunshade handles, and are very much used for that purpose. They are imported from China.

Whangee.—This is a well-known cane imported from Japan, and is formed of the rhizome or underground stem of a kind of bamboo (*Phyllostachys nigra*). The cane is very pliable, and is very distinctly marked by the transverse scars of the young shoots, where they have died out, and where the rootlets have fallen off. The canes are mostly of a pale yellow colour, but there is a variety with black scars known as the black whangee.

Whitethorn.—This is another name for hawthorn (*Cratægus Oxyacantha*). The wood is very hard and close-grained, and makes very strong sticks.

Zirracote.—A close-grained, nearly black wood; used mostly as a cabinet wood. It takes a good polish, and has a very handsome appearance. (J. R. Jackson).

Method of Treatment.—Walking-sticks should not be cut or pulled later in spring than February, nor earlier in autumn than October, the best time being from early December to mid-February. They should not be stripped of bark nor worked till half dry, and meantime should be stored in a cool and moderately dry place. It is best to leave all roots and spurs on the stick about 1 in. long when laying aside to dry. When half dry their suppleness is at its greatest, and working is facilitated.

Holly sticks must be only rough trimmed when put away to season. Ash sticks must also be rough trimmed and well seasoned before they are barked and polished. The wood and curiously-formed root-knobs of ground ash admit of excellent grotesque carving.

Of all home-grown sticks oak is the most reliable, and stout oaken cudgels are esteemed by most persons as some of the best props to failing legs, as well as the best weapons for self-defence against quarrelsome dogs and rowdy ruffians. Straight sticks of sapling oak are not always easily obtained, but copse-wood sticks pulled from the stumps of trees form excellent substitutes. Those should be selected for walking-sticks which taper gradually from ¾ in. just below the knob or crutch, down to ½ in. at the opposite end. Gnarled and crooked oak sticks are sometimes fancied, and heavy cudgels are sometimes selected for defensive purposes. Oak sticks split in drying when the bark has been stripped off, or the knots cut too close, or the sticks put away to dry in a very warm dry place; they are then rendered useless for walking-sticks and cudgels. The wood and also the form of the knobs or roots will admit of much taste being displayed in carving.

From the roots of elm trees, saplings with a coating of rough bark will shoot up straight to a height of 10–12 ft. These will furnish good walking-sticks of the fancy type, the rough bark serving the purpose of ornamentation when the sticks are dried, stained, varnished, and polished. The wood is also durable, but not very supple when dried, and sticks of it are not suitable to hard usage. The usual precautions must be taken in drying them.

Light sticks of hazel may be cut or pulled from almost every hedgerow and in any wood. Saplings are not unfrequently found of most symmetrical proportions, tapering from 1 in. down to ½ in. through a length of 10–12 ft.; these are used by country swains as goads for the oxen, and form very tough sticks. The wood is very light, but it has the disadvantage of bending and remaining crooked when leaned upon heavily. It is also soft, and may be easily carved. Occasionally, hazel sticks may be found grotesquely entwined with honeysuckle, and the stem so deeply furrowed with the supple vine as to enclose the convolutions of the climber. Sticks of this kind are valued as fancy sticks, and look well when properly prepared, varnished and polished.

In exposed positions the blackthorn is only a dwarf shrub, but in sheltered hedgerows and woodlands it attains a height of 20 ft., and its saplings run up to a length of 6–8 ft. straight and taper, but covered with stout spines and small twigs. These saplings make excellent walking-sticks, both when they can be dug or pulled up, and also when they have to be cut off. The spines and twigs must not be cut off close until the stick is half dried, and then cut with a sharp knife; in fact, the knots from the spines and twigs when left as slight round excrescences enhance the beauty of the finished stick. Blackthorn is more famous for its hardness, strength, stability, and durability, than for lightness, elasticity, and suppleness. A cudgel made of blackthorn will deal heavy blows, but when matched against one of oak would splinter at the knots, the oak being the tougher stick. The wood is hard and not easily carved, but the root knobs will admit of a very fine and smooth polish, most grateful to the palm of the hand of the tired pedestrian. Its congener, the whitethorn or hawthorn, is not so suitable for walking-sticks, being more brittle and less durable.

Among fruit trees the cherry will furnish some very nice fancy sticks, supple, and of tolerable strength: and apple wood, when well and carefully dried, will yield some good sticks. Grape vine and briar sticks cannot be relied upon for stability when leaned upon.

When sticks are half-dried, that is, when the bark is shrunken, has lost its sappy greenness, and refuses to peel freely, they may be trimmed, straightened, or bent as required. To bend or to straighten them, they may be held over steam until rendered supple, or buried in hot wet sand until this end has been attained; they must then be given the form they are intended to assume (whilst still hot), and kept in this form until they are cold, straight sticks being tied firmly in small bundles, and wound with a coil of rope from end to end, or suspended from the beam by the knob end whilst a heavy weight is hung from the small end. Crooks may be turned by immersing the end in boiling water for 5-10 minutes then bending it to the desired form, and securing it in this position with a tourniquet (Fig. 294 A) until the stick is cold. The bark may next be taken off with a sharp knife, if so required, and care must be taken not to splinter or chip the wood of the stick. Knots may be trimmed at the same time, and the knob trimmed up to shape. Hard and fast rules cannot be given for the formation of knobs, since their form must be regulated by the natural knobs, and these are often very suggestive in themselves. One or two things should, however, receive consideration in designing a knob, and the first should be the ultimate use of the stick. If the stick is to be a fancy one, to be carried and swung in the hand, more for appearance than for use, then any amount of skill in carvings may be expended on the knob; but if the stick is for use, we should first consider its use. Round smooth headed knobs (Fig. 294 B) carved and polished to fit comfortably into the middle of the hand, will meet with most acceptance from those who use a stick as a support. But knobs thus formed, and shorn of a projecting crook or hook, often slip from beneath the arm or out of the hand when its owner wishes to use both hands for some purpose. The head of a dog with a long muzzle, the head of a swan or a goose, forms an appropriate design for such a stick. The crutch (Fig. 294 C) or half-crutch form (Fig. 294 D) is also a comfortable one, but the ordinary crook (Fig. 294 A), although useful for many other purposes, does not fit comfortably in the hand, it is too much of a handful, and the central support usually finds its bearing under the forefinger instead of the palm of the hand. Sharp carving on the knob should always be discouraged, for it only hurts the hand, but the neck of the knob may receive the carver's attention.

Elm sticks with the rough bark left on (Fig. 294 E) must be neatly trimmed, naked around the neck of the knob, and at the bottom of the stick just above the ferrule, loose bark should also be neatly trimmed with a sharp knife, and the whole lightly gone over with medium glass-paper. The stick should then receive a dressing of boiled linseed oil, and be left to dry. When dry, it will be well to go over the smooth parts with a little polish, and finally give one or two coats of hard spirit or copal varnish. Holly, ash, hazel, cherry, apple, birch, etc., should have part of their bark only taken off with a sharp knife, leaving all knots smoothly trimmed, rounded, and clean. The sticks should be then lightly glass-papered, and, when smooth, dressed with boiled linseed oil, dried, polished, and varnished. Oak sticks look best when carefully barked in hot water, cleared of the loose bark by rubbing with canvas, dried, dressed with boiled linseed oil, again dried, then polished and varnished with oak varnish. Blackthorn sticks should be only partly barked, the knots smoothly trimmed, then glass-papered quite smooth, dressed and varnished as directed for other sticks. Sticks may be stained black after they have been glass-papered, and before they are dressed with oil, by first brushing them over with a hot and strong decoction of logwood and nut-galls, and when this has well dried, brushing over them some vinegar or acetic acid in which a quantity of proto-sulphate of iron, some iron rust, or some old rusty nails have been steeped some 2–3 days previously. A brown or mahogany tint may be given by adding some dragon's blood to the polish, and a yellow tint may be obtained by adding yellow ochre. Some persons use ink for a black stain, and others put drop black in the varnish, but the black stain above mentioned is preferable to all others. The sticks are to be polished and varnished after the stain is dry. The bottom ends of walking-sticks should be guarded from excessive wear by a neat brass ferrule, but these are more cheaply bought than made. They should be secured to the stick by two small screws, one on each side of the stick, to prevent them from coming off when they get loose in dry weather.

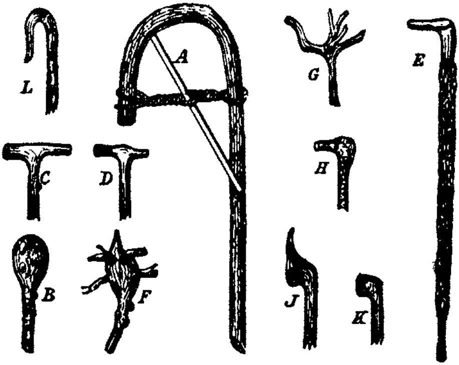

FIG. 294.

The remaining diagrams in Fig. 294 indicate as follows: F, blackthorn knob in the rough; G, ash root as dug up; H, ash root trimmed; J, ash or oak knob as pulled from pollard or stump; K, the same trimmed; L, stick bent and trimmed to form a crook. (G. Edwinson).

Staining.—(*a*) Use Judson's simple dyes; they are so clean, and moreover so economical in their application that they take the leading part in all work of fancy or intricate workmanship. Put the stains on with a camel-hair brush, diluted with water. For dark stains use copal varnish, or purchase some from a coach painter. For light woods use the light crystallised varnish, such as is used for the tops of washstands, etc. Old damaged sticks that are varnished should have the varnish eaten off with liquor ammoniæ, then rinsed, scoured, stained, and varnished again.

(*b*) Make a solution of 3 parts glue in 100 of warm water; to this add 1 part whiting, 2 parts orange chrome. Mix well. Apply hot with a soft brush to your sticks. When thoroughly dry, rub down with a piece of dry flannel. Apply a second coat of colour if deeper tints be required, or use burnt umber and brown ochre for oak tints. When dry, apply the following varnish :—Coarsely-powdered copal and glass, each 1 oz.; alcohol, 64 o.p., 1 pint; camphor, ½ oz. To be heated over a water bath, with constant stirring, until the copal is dissolved. When cold, decant the clear portion. Be careful that the alcohol does not inflame.

Straightening. — Straightening requires a good deal of judgment and some skill. A bed of wet sand is provided and kept at about the temperature of boiling water. Into this the stick is plunged for some time, which renders it quite pliable, and it is then straightened by hand, pushing the stick through a hole in a bench and bending each part as may be necessary until the whole is straight, much the same as is done with bamboo. When straightened, sticks should be hung in some dry, airy space, not too hot, that they may dry. If a large number are done at once, they may be tied in a bundle, keeping each other straight. Here they should be left until thoroughly seasoned before screws or cords are removed. The knots should be trimmed up with a small plane or spokeshave. Then the whole may be rubbed down with fine sandpaper—the finer the sandpapering the better the stick—and finished with a hard drying varnish, with or without stain. A good polish for walking-canes and other hardwood: Fill with best clear filler or with shellac, dry by heating, rub down with pumice, put on three coats of clear spirit copal varnish, hardening each in oven with temperature as hot as wood and gum will safely stand. For extra work, the first two coats may be rubbed down and the last allowed a flowing coat. For coloured grounds, alcoholic shellac varnish with any suitable pigment (very finely ground in) can be used.

Polishing Malacca Cane.—To repolish a scratched malacca cane first wipe it over with raw linseed oil, next smooth down all roughness and scratches with fine grade glass or emery cloth, then wipe free of oil. When a cane is of a reddish tinge one or two coats of mahogany furniture varnish may be applied with a camel-hair brush, but if required clear a brown hard spirit varnish is used. As a rule all varnishes dry too bright for walking canes, therefore the wipe of linseed oil is first given (when the varnish is dry and hard) then putty powder or jewellers' rouge with oil, is rubbed on with a woollen cloth. Finish with dry powder and washleather, and a smooth satin gloss will take the place of the bright shine of the varnish.

* * *

WASTE METAL:

ITS
RECOVERY AND UTILISATION.

IN the present day of commercial economy, one of the most interesting problems is the utilisation of waste products, many fortunes having been largely built upon the application of some cleverly discovered process for extracting or recovering good material from waste. The following recipes refer wholly to metallic substances and solutions that are commonly looked upon as useless, or nearly so, and more or less a source of loss.

Copper Salts.—In works where a large quantity of copper is dealt with, this metal is worth recovery from the cleansing baths. Collect all the liquids holding copper in a large cask filled with wrought or cast iron scraps; a chemical reaction immediately takes place, the iron is substituted for the copper to make a soluble salt, and copper falls to the bottom of the cask in the shape of a brown powder. The cask should be large enough to hold all the liquids employed in a day's work. The iron scrap should be suspended in willow baskets on the top of the liquor, and, by stirring now and then the liquid with them, the metallic powder of copper will alone fall to the bottom of the cask. The same method may be employed for recovering the copper from old cleansing acids, or from worn out galvanoplastic baths. The copper thus obtained is quite pure; calcining it in contact with the air, gives a black binoxide of copper for neutralising too acid galvanoplastic baths.

Gun Metal, or Red Brass Turnings, Filings and Scrap.—These are frequently sold for a low price, even by establishments having facilities for casting in crucibles, because they are apparently not fit for casting. These turnings can, however, be profitably utilised for new castings as well as an addition to other charges. The process is as follows:—The turnings are melted by themselves, and during the melting process mixed with manganic oxide in the proportion of 5 parts, by weight, of manganese to 100 of turnings. In charging for melting, it is advisable to cover the bottom of the graphite crucible ⅓ in. deep with manganic oxide; upon this is placed a layer of turnings about 1¼ in. deep, and so on until the crucible is full. During melting the impurities contained in the turnings settle on the surface and can be readily removed with a graphite ladle. The melt is best cast in buttons (square pieces). When cool each button is cut, in order to determine the qualities of the metal by the fractured surfaces. The metal melted in this manner shows a reddish, nearly coppery fracture, and is very tenacious and dense. An addition of manganic oxide, not exceeding, however, 2½ per cent., to new material for melting is also recommended. With this method the crucible should not be covered with tallow, fat, pitch, etc. Boxes for rapidly running parts of machines show great durability, being but little worn after years of use.

Gold.—(*a*) All the liquids which contain gold, except those in which there is a cyanide, are strongly acidulated by sulphuric or hydrochloric acid, unless they are already acid, and then largely diluted with water. Precipitate the precious metal by a solution of sulphate of protoxide of iron (copperas), and, after a few hours standing, it is ascertained that the liquor does not contain any more gold when a new addition of iron sulphate does not produce any turbidity. The precipitated gold is in the form of a red or black powder; collect upon a filter, wash, and dry in an iron pan, with weights equal to its own, of borax, saltpetre, and potash carbonate. Gradually introduce the powder into a refractory crucible heated to a white heat in a good air-furnace. When all is introduced, increase the heat and close the furnace, so that all the metal may fall to the bottom of the crucible.

After cooling, extract the button of pure gold which remains. If it is desired to dissolve the powdered gold left on the filter in aqua regia, it will be necessary to wash it several times with dilute sulphuric acid, to remove the iron sulphate with which it is impregnated. This mode of reduction is adapted to an impure gold chloride, to the baths by dipping with soda bicarbonate or pyrophosphate, and also to the ungilding acids; but it is imperfect with baths holding a cyanide, which never completely part with all the gold they contain by this process. The best manner of treating the latter liquors is to evaporate them to dryness in a cast-iron kettle, and calcine the residue to a white heat in a good crucible. A small proportion of borax or saltpetre may be added to aid the fusion, but generally it is uunecessary. The resulting button of gold at the bottom of the crucible is red when saltpetre has been employed, and green with borax; but these differences of colour have nothing to do with the purity of the metal.

(*b*) Gold may be separated from liquors which contain no cyanide, by an excess of tin protochloride, which produces a precipitate easily reduced by heat. Sulphurous acid will also reduce the gold; but in this case, the liquor should be heated. Granulated gold is obtained by running the molten metal, in a small stream, and from a certain height, into a large quantity of cold water.

(*c*) Sweepings, saw-dust, residues from the bottoms of scratch-brushing tubs, filters, papers, and rags, must be collected, mixed, and burned in a furnace constructed for the purpose. The ashes are finely pulverised, sifted, and thoroughly mixed with a quantity of mercury, which combines with the gold and silver. The amalgams, separated by washing, are then distilled in cast-iron retorts of a peculiar shape. The mercury volatilises, and the gold and silver remain in the retort. For separating these metals, granulate the solid mass and treat with pure nitric acid, which dissolves the silver, and is without action upon the gold. The latter metal collects at the bottom of the vessel in a black or violet powder, and is pure, after having been washed in distilled water. If an ingot contains only a little silver and much gold, melt previously with a certain proportion of the former metal, in order to more easily dissolve in nitric acid. The ingots of silver and copper should be boiled in cast-iron kettles with concentrated sulphuric acid, which transforms the copper into soluble sulphate, and silver into sulphate, only slightly soluble. The separation of the two may be partly effected by washing, but, generally, the silver is precipitated by plates of copper. The alloy, previous to its solution, should be granulated.

(*d*) An easy method to recover gold from solutions, particularly from old toning-baths of photographers, has been made known by Haugk. It consists in filtering the solution into a white glass flask or bottle, making it alkaline with sodium bicarbonate, and then adding drop by drop, a concentrated alcoholic solution of aniline red (fuchsine), until the liquid retains a deep strawberry colour. The flask is then exposed to the sunlight for 6–8 hours, at the end of which all the gold still present will have been precipitated as a dark violet powder, and the liquid will have become colourless. After pouring off the liquid, the flask, with its precipitate, is kept until a fresh quantity of solution has to be precipitated, and this is continued until the deposit in the flask is sufficiently large to make it worth while to remove it. It is then transferred to a filter, washed, dried, and burned with the filter. The residue containing the filter-ash is dissolved at a gentle heat in aqua regia, filtered, and the solution is evaporated to dryness. The quantity of impurity caused by the simultaneous solution of the filter-ash is too insignificant to be objected to.

(*e*) Although sheet zinc, or zinc and iron sheets, serve well for the precipitation of silver, they cannot be employed for the recovery of gold. The latter separates out in such a case very incompletely and as a firmly adhering lustrous film in the zinc. On the other hand, finely divided zinc, the so-called zinc dust, is an excellent substance to employ for precipitating gold quantitatively and in the form of powder from spent cyanide liquors. When zinc dust is added to a spent gold bath and the liquid is periodically stirred or shaken, all the gold is precipitated in 2-3 days. The amount of zinc to be added naturally depends on the quantity of gold present. Freshly prepared gold baths for gilding in the cold contain on the average 3·5 grm. gold per litre; whilst those used for the hot process contain 0·75 grm. To precipitate all the gold in the original bath, 1·74 grm. or 0·37—0·5 grm. zinc dust would be necessary, and, of course, a much smaller quantity would be sufficient for the spent liquors. Since the precipitation takes place more rapidly when an excess of zinc dust is present, it is generally advisable to add ¼ or at the most ½ kilo. of zinc dust to every 100 litres of solution.

The precipitated gold, which contains zinc dust and usually silver and copper, is washed, freed from zinc by hydrochloric acid, and then from silver and copper by nitric acid and thus obtained pure.

A spent bath treated in this way gave the following amounts of gold per litre :—

1st experiment .	0·2626 grm.
2nd ,, .	0·2634 ,,
Mean	0·2630 ,,

The presence of gold in the residual cyanide solution could not be qualitatively detected. The potassium cyanide of the solutions obtained by this process should be converted into ferrocyanide by heating with ferrous sulphate and milk of lime, since this substance is not poisonous, and can therefore be got rid of without danger. It would, however, be more economical, and, considering the large amount of cyanide present, more profitable to work it up into Prussian blue.

Recovery of Gold from Gold Baths, etc.—To recover the gold from old cyanide gilding baths, evaporate the baths to dryness, mix the residue with litharge and fuse the mixture. The gold is contained in the lead button thus obtained. The latter is then dissolved in nitric acid, whereby the gold remains behind in the form of insoluble spangles. These spangles are filtered off and dissolved in aqua regia.

The following method is used for the recovery of the gold by the *wet process* :—The bath containing gold, silver and copper is acidulated with hydrochloric acid, which causes a disengagement of hydrocyanic acid. This gas is extremely poisonous, for which reason the operation should be carried on in the open air, or where there is a good draft or ventilation to carry off the fumes. A precipitate consisting of the cyanides of gold and copper, and chloride of silver, is formed. This is well washed and boiled in aqua regia, which dissolves the gold and copper as chlorides, leaving the chloride of silver behind. The solution containing the gold and copper is evaporated nearly to dryness, in order to remove the excess of acid, the residue is dissolved in a small quantity of water, and the gold precipitated therefrom as a brown metallic powder, by the addition of sulphate of iron (copperas). The copper remains in solution.

Gold and Silver from Sweepings, and Refuse of Gold Worker's Shops.—Collect the sweepings, dry them, if necessary, and heat them in a Hessian crucible, in order to destroy all the organic substances. Triturate the glowed mass in a porcelain dish or enamelled kettle with water, and treat it with an excess of hydrochloric acid to dissolve any alkalies or calcium carbonate present. The portion remaining undissolved contains gold, silver, copper, sand, clay, ferric oxide, etc. To recover the silver from it, wash it thoroughly with distilled water, and boil it in pure nitric acid, which absorbs the silver. The residue is again thoroughly washed, and from the combined fluids the silver is precipitated as chloride of silver by common salt, or, still better, by hydrochloric acid. The residue remaining undissolved after the treatment with hydrochloric acid is heated with aqua regia, and the gold precipitated by the addition of sulphate of iron (copperas). Sometimes it may pay to treat the residue remaining undissolved in aqua regia with ammonia in order to extract the chloride of silver, the formation of which under the given conditions can scarcely be prevented. An experiment with a small portion will show whether such treatment is advisable or not.

Gold from Gilded Articles.—Gilded articles of *iron* and *steel* are best ungilded by treating them as the anode in a solution of from 2 to 2¾ oz. of 98 per cent. potassium cyanide in 1 qt. of water, and suspending a copper plate greased with oil or tallow as the cathode. Gilded *silver-ware* is readily ungilded by heating it to glowing, and then immersing it in dilute sulphuric acid, whereby the layer of gold cracks off, the glowing and immersing in dilute sulphuric acid being repeated until all the gold is removed. Before glowing and immersing in dilute sulphuric acid the articles may first be provided with a coating of a paste of sal-ammoniac, flowers of sulphur, borax and potassium nitrate, which is allowed to dry. On the bottom of the vessel containing the dilute sulphuric acid the gold will be found in the form of laminæ and scales. These are boiled with pure sulphuric acid, washed, and finally dissolved in aqua regia and made into chloride of gold or fulminating gold.

To ungild articles of *silver*, *copper* or *German silver*, which will not bear glowing, the solution of the gold may be effected in a mixture of 1 lb. of fuming sulphuric acid, 2·64 oz. of concentrated hydrochloric acid and 1·3 oz. of nitric acid of 40° Bé. Dip the articles in this warm acid mixture, and observe the progressive action of the mixture by frequently removing the articles from it. The articles to be treated must be perfectly dry before dipping them in the mixture, and care must be had to preserve the latter from dilution with water, in order to prevent the acids from acting upon the base-metals.

Platinum.—(*a*) Render any kind of platinum bath acid by hydrochloric acid, unless it is already so, and then plunge cleansed iron into it. The platinum is reduced to a black powder, wash, and calcine to a white heat. Dissolving it in aqua regia reconstitutes the platinum chloride necessary for the preparation of the baths. Reduce by evaporating the bath to dryness, strongly calcine the residue, then wash upon a filter to remove the soluble salts, and again heat to a white heat. The platinum thus obtained is soluble in aqua regia.

(*b*) From not too large baths precipitation of the platinum with sulphuretted hydrogen is the most suitable method, and preferable to evaporating and reducing the metal from the residue. The process is as follows:—Acidulate the platinum solution with hydrochloric acid, and, after warming it, conduct sulphuretted hydrogen into it. The metal (together with any copper present) precipitates as sulphide of platinum. The precipitate is filtered off, dried and glowed in the air, whereby metallic platinum remains behind. From larger baths the platinum may be precipitated by suspending bright sheets of iron in the acidulated bath. In both cases the precipitated platinum is treated with dilute nitric acid in order to dissolve any copper present. After filtering off and washing the pure platinum it is dissolved in aqua regia; the solution is then evaporated to dryness in the water bath, and the chloride of platinum thus obtained may be used in making a new bath.

(*c*) The old developing-baths for platinotype paper, odd bits of the paper itself, spoilt prints, etc., all may be reworked. Old developers may be treated with saturated solution of iron sulphate—1 part of the saturated solution to 4 parts of the developer will be about right; the mixture should be heated to boiling in a porcelain dish, and the precipitated metal collected on a filter. Bad prints, clippings, etc., of the paper, should be placed on a tin or iron plate and burned, the ashes collected and digested for some hours at 122°-158° F. with aqua regia, and then the solution diluted with an equal volume of water, and the platinum precipitated with iron as above, or with ammonium, or soda formate, or any other reducing agent.

Silver.—It is a fact that only about 5 per cent. of the gold and silver used in producing a photograph remains on the finished picture; the balance is lost, and below are given a few short and simple methods of saving and reducing photographic wastes and residues.

(*a*) Old baths and the washings of the prints should be precipitated with ordinary salt, thereby forming silver chloride. Add the salt gradually, stirring up the solution, until it forms no longer a precipitate, which you may easily determine by taking a sample of it in a tumbler or white bottle, holding it up to the light when adding a little salt. Do not add too much, as an excess will redissolve the chloride. When the silver is all down, pour in a little acid, either nitric, sulphuric, or muriatic, which will clear the solution; allow it to stand for about 24 hours, then draw off your clear water and you have the chloride on the bottom of the vessel.

(*b*) The hypo or fixing solution is very rich. It should be precipitated with potassium sulphide previously dissolved in water, also adding it as long as it will form a precipitate. The latter, when down, may be thrown on a plain muslin filter to allow the water to drain off. Such a filter may be readily constructed by taking a piece of common unbleached muslin, say a yard square, tying loops to the four corners, and hanging it up on sticks.

(*c*) A good many photographers are in the habit of precipitating their washing solutions with metallic zinc expanded in sheets therein. The action of zinc, however, is slow, and must be accelerated by acidifying the solution. Now it frequently happens that the fixing solution is allowed to run into the same vessel, and, the hyposulphite being an alkali, suspends the action of the zinc. In the course of time a deposit out of the water is formed; but the proprietors of the "mud" are sadly disappointed in its value, as it is sometimes even so poor as not to pay for the trouble of refining.

(*d*) All prints should be trimmed before toning, as it saves gold, and, besides, toned paper is of hardly any value. Keep the untoned clippings and filters clean by themselves; do not throw sweepings, pieces of glass, and spoiled ferrotype plates among them, as their bulk only decreases the real value. If you wish to burn the paper, have your stove cleared of cinders and ashes, and proceed slowly, for a good draught will carry many particles of silver through the flue.

(*e*) Your toning solution throw down with iron sulphate, but be sure and have the solution "acid," as otherwise the iron will be precipitated, and your gold goes up the chimney. Save your developer and collodion skins; they will also amount to something in the course of time.

(*f*) Sometimes the wood of barrels which contained waste solutions for a number of years is quite impregnated with silver, some barrels yielding as much as 30 oz. of metal; so, when yours are unfit for further use, you know what to do with them.

(*g*) Last, but not least, do not send small lots of waste to be refined, but wait until you have a reasonable quantity for expenses, and charges are then comparatively less.

(*h*) Common salt is without action upon the liquids which hold silver in the state of a double salt, and will rather aid the solution than the precipitation; such are the double tartrate of silver and potash, whitening bath, the double sulphite of soda and silver, and the bath for dipping. Before employing common salt, add sulphuric acid, which, displacing the other acids, restores the silver to the state of a simple salt, easily precipitated by common salt. Hydrochloric acid alone precipitates silver well from these solutions. Liquors containing silver as cyanide are also exceptions; to extract all the metal, use the process employed for similar combinations of gold, evaporate to dryness, and reduce the mass in a crucible, with an addition of soda carbonate and powdered charcoal. The metallic silver remains at the bottom of the crucible.

(*i*) Baths of silver cyanide, the residues from galvano-plastic establishments, are precipitated with sulphuric acid. The precipitate contains all the silver, along with copper, zinc, and iron. It is ignited, and the residue is treated with nitric acid, which dissolves out the silver, zinc, and copper. From this solution the silver is thrown down as chloride. The portion insoluble in nitric acid contains carbon, ferric oxide, and traces of silver, which may be extracted with ammonia.

(*k*) Filter the solution of silver proposed to be operated upon until it is clear, and place the filtrate in a clean white bottle of suitable capacity. To each pint of the liquid add 4 oz. or more of mercury, and allow the mixture to remain at perfect rest for a few days. In a very few hours a beautiful sparkling coruscation will be found forming upon the surface of the mercury by what is known as double elective affinity, and for each atom of the silver so deposited, a corresponding amount of mercury is acted upon by the nitric acid of the silver, and passes into solution as mercury nitrate. The deposition continues until all the silver has been thrown down, when we find over it a strong solution of mercury nitrate, which may be obtained in the solid crystalline form by evaporation. In a few days the deposition will be completed, which can be readily seen if the tree ceases to grow. Shake the bottle thoroughly, so that the branches of the tree are detached and broken, and brought in thorough contact with the mercury, where the spangles of silver are quickly dissolved. The watery part of the mixture can now be drawn or decanted off from the mercury, and the latter placed in a bag, or, better, in a large piece of fine tough buckskin, and pressed with force between the hands. When no more mercury can be squeezed through, the bag may be opened and the lump of brittle amalgam removed, and preserved in a well-cleaned and stoppered bottle until more has been accumulated. In case all the mercury should disappear at the end of the process, a little more may be added to the watery solution to ascertain whether it still contains silver.

(*l*) A method of reducing silver chloride to the metallic state, especially adapted to the practice of amateurs, formed the subject of a paper read before the Manchester Photographic Society by Mr. J. Leigh.

Many amateurs, said the author, trouble themselves very little about the reduction of photographic silver wastes, simply because they consider their small quantities not worth sending to a professional refiner, or that the process of reduction to the metallic state is troublesome and not worth the expense. The process about to be described is simple, effectual and economical, and particularly suited to the amateur who has comparatively small quantities to operate upon. As regards the precipitation of Ag Cl from solutions containing Ag NO$_3$ we all make use of common salt. In my dark room is a large inverted bell-glass, into which are poured the washing waters of dry plates and paper prints, the rinsings of glasses, baths, and other vessels which have contained Ag NO$_3$ in solution; and, at the end of the season, all the nitrate baths are added to be precipitated as Ag Cl by the process just mentioned. The precipitated chloride should be well washed by decantation, dried, and weighed, or it may be poured into the evaporating basin without washing. Add to the Ag Cl about its own weight of KOH or Na OH, and half its weight of cane sugar with sufficient water to well cover the whole, and boil for about 15 minutes over a Bunsen's burner. This solution turns muddy on applying the heat, but in a few minutes gets somewhat clearer, owing to the reduction of the silver, which settles on the bottom of the basin in the form of a grey powder, lacking altogether the metallic lustre of silver cast into ingots or buttons. The finely divided silver is transferred to a precipitating beaker and well washed by decantation. The clear washing water is now tested with $AgNO_3$ until no precipitate is obtained; the silver is then washed in two changes of distilled water. There is nothing new in the above process; it is based upon the fact that solutions of sucrose or dextrose in the presence of alkalies, reduce the salts of the noble metals to the metallic state; the chlorine, in the case of chlorides, remaining in solution.

At the commencement I stated that this was an effectual method of reducing Ag Cl, which I think I can prove. From one precipitation I had 5663 gr. of dried Ag Cl, which, according to calculation, would yield 4262 gr. of pure silver. I actually got 4250 gr., being a loss of 12 gr., possibly accounted for by the chloride having absorbed moisture between drying and weighing; or probably a small quantity of kaolin may have been mixed with the chloride. The process is also economical, NaOH costing about 4*d*. per lb., and sugar about 1½*d*. per ½ lb., which is sufficient to reduce considerably more than 1 lb. of Ag Cl to the metallic state, without the expense of building a furnace; also less the risk of a broken crucible, and possibly, the trouble of collecting the precious metal from the remains of a coke fire, which is anything but amusement. Those who prefer a crucible can obtain sufficient heat on an ordinary blacksmith's hearth, with a small coal fire.

(*m*) Put well-washed silver chloride into an iron ladle, with a little pure water above the chloride. The greater affinity of iron for chlorine determines its departure from the silver; and, after standing 24–30 hours, throw the contents of the ladle upon a filter, and wash thoroughly with pure water to remove the soluble iron chloride; the residue will be pure silver in a minute state of division. This method is rarely employed, on account of the length of time required.

(*n*) Well-washed silver chloride (water does not dissolve a trace of it) is put into a stoneware pan with two or three times its weight of zinc, and the whole is covered with water rendered acid by sulphuric acid. As soon as they are in contact these substances react upon each other; the sulphuric acid and the zinc decompose the water, the oxygen of which oxidises the zinc, which then combines with the acid, and forms zinc sulphate, a very soluble salt; the hydrogen transforms the chlorine of the silver into hydrochloric acid, which is also very soluble in water. Before filtering, wait until all the zinc is dissolved. The remaining silver is in impalpable powder, and cannot pass through the filter. Wash the silver thoroughly with pure water, and it may then be dissolved in pure nitric acid to form a pure silver nitrate. This process is seldom employed, as it is difficult to find zinc without lead, which will unite with and follow the silver in subsequent manipulations.

(*o*) The silver chloride, freed from foreign metallic salts by washing, is mixed with four times its own weight of crystallised soda carbonate, and half its weight of pulverised charcoal. Make into a homogeneous paste, dry thoroughly in an iron pan, and then place in a red-hot crucible. After fusion the heat is raised, in order to allow the smallest globules to reach the bottom of the crucible. Should the crucible be moved at the time of the solidification, the silver will be of a very irregular shape. To obtain granulated silver pour it in a small stream, and from a height, into a large volume of water.

(*p*) To recover silver from trimmings of untoned prints, procure an old iron bucket or pot, and place the cuttings in a few handfuls at a time, and apply a light to them, when they will quickly burn to ashes. As they burn down, keep adding the cuttings, which must be stirred up frequently with an iron rod, so as to completely reduce all the mass to fine ashes. Of course the burning must be done out of doors, owing to the dense smoke and disagreeable fumes. If in windy weather, place a piece of sheet iron partly over the bucket to prevent the ashes from blowing away. The fire will be a long time dying out. After the trimmings are reduced to ashes, the ashes can then be reduced to metallic silver in a crucible with equal quantities of soda carbonate and borax.

(*q*) The residues almost always exist as silver chloride. Wash by decantation, with plenty of water, in a capacious vessel which can be shaken, the mass—filter-paper and all—till free from copper, etc. Next drain off as much water as possible, and add strong ammonia, and after a time filter to get a clear solution. Place this in a wide-mouthed bottle, which fit with a cork. Through the cork pass two wires, to one of which attach a cathode of a strip of silver, and to the other an anode of lead. Lastly, connect a Daniell cell, and leave to itself for a day or two. The strip of silver will then be found studded with crystals of the reduced metal, while the lead will have a scale of lead chloride, some of which may have fallen to the bottom of the bottle. The ammonia is then shaken up, with the remaining undissolved residue, the lead is scraped, and the cell is recharged, when all is again ready to proceed for another two or three days. It is obvious that a bag of the washed residues can be suspended in the electrolytic bath. It is not a process to be recommended if rapidity is an object; but this is often of no consideration whatever. I do not recommend it for large quantities, though under certain circumstances it might answer even then; but for small quantities, such as pints or quarts, I certainly do, and claim for it the following advantages: First and greatest. Less expenditure of superintending time and trouble than any other. The time expended in preparing the ammoniacal solution is but a few minutes. That expended in charging the cell is about the same, and besides these there is absolutely nothing to do beyond occasionally scraping the lead anode and collecting the silver crystals, after the easily fitted up and simple apparatus necessary has been procured. Second, small cost of apparatus and materials. Those consumed are zinc, copper sulphate, and lead. The ammonia will do over and over again, for the cork prevents its dissipation, and the loss in manipulation need be very small. Third, there is less mess and disagreeable work than any other method I know of. Fourth, the silver is obtained in a convenient form for future use, which is usually to prepare the reagent, silver nitrate. I have tried the method of reducing by means of zinc, but found these disadvantages and difficulties:—First, it is not easy to ascertain when all the chloride is reduced. Second, washing the metallic silver powder free from zinc chloride is a matter which takes a very considerable time. Third, the process is messy and disagreeable. Fourth, the reduced metal cannot be very pure, for ordinary zinc always contains a little lead, which would remain with the silver. I have also tried reduction by means of glucose, though not very thoroughly, finding it take time and trouble. The process of reduction with soda carbonate in a crucible is the worst of all in my estimation for small quantities. The time is greater than any others, and the heating of the crucible without special apparatus is most troublesome, to say nothing of the fuel consumed. Moreover, whatever others may find, I have always observed numerous little beads of silver scattered in a most aggravating manner all over the pot, which it is impossible to collect. I may mention that by the electrolytic method described, every trace of silver leaves the solution after a time, as may be proved by neutralising with an acid. One word more. It might be worth while dipping the ends of exposed iron into melted paraffin wax before placing in the electric bath.—(L. S. Powell).

(*r*) A process invented by Stockmuir and Fleischmann, and worked out by them in the chemical laboratory of the Bavarian Industrial Museum, is exceedingly simple, and is employed in many establishments. In order to remove silver from a potassium cyanide silver solution, it is only necessary to allow a clean piece of plate zinc to remain in the liquid for two days; even better results are obtained by the use of iron conjointly with the zinc. In the first case, the silver often adheres firmly to the zinc, whilst in the second it always separates out as a powder. It is then only necessary to wash the precipitated powder which usually contains copper (since spent silver solutions always contain copper), dry it, and then dissolve it in hot concentrated sulphuric acid, water being added, and the dissolved silver is precipitated by strips of copper. The silver thus obtained is perfectly pure. If the amount of copper present is only small, it can usually be removed by fusing the precipitated powder with a little nitre and borax.

In this way a spent silver bath was found to contain per litre—

First experiment .	1·5706 grm.
Second ,, .	1·5694
Mean	1·5700

The presence of silver could not be qualitatively ascertained in the residual liquor.

(*s*) After soaking the prints for five minutes in water made slightly acid by acetic acid, remove them to another dish, and add to the water from which you have just taken them about a teaspoonful of salt; stir it rapidly for a moment with the hand, when it becomes as white and thick as milk. This solution is then poured into a common wooden pail, which will hold enough water for the first washing of a hundred prints, and the next day, when ready to tone again, you will find that the solution has become perfectly clear, and in the bottom of the pail is a clear white sediment—pure silver chloride. Then pour off the water to within an inch of the bottom, and the pail is ready to be filled again.

On adding salt to the second water in which you washed the prints, there is hardly a trace of silver and it is not worth saving. About once a month, pour the settlings from the pail through a fine cloth to filter it, and throw the cloth and contents into the silver paper clippings. In this way you will save more than half the silver used in making the print.—(A. C. Hopkins).

(*t*) To separate silver bromide from waste emulsion, Scola recommends that 2–3 per cent. of sulphuric acid should be added, and the mixture should be boiled for some minutes, after which the bromide settles rapidly to the bottom of the vessel. It is now washed and dried, when it is ready to be cast into sticks for use in the battery about to be described.

The battery in which the reduction is effected is constructed on precisely the same principles as the silver chloride battery of Warren de la Rue, and one form of this, as is well known, consists of a rod of amalgamated zinc immersed in acidulated water, and opposed to a similar rod of fused silver chloride, a platinum wire being embedded in this latter to serve as a conducting terminal. When the plates of the battery are connected by a conducting circuit, the silver chloride becomes reduced to the condition of metallic silver, while the chlorine unites with some of the zinc to form zinc chloride.

If the negative plate of the battery

is made of fused silver bromide, reduction takes place quite readily when the terminals are united; and when the battery is exhausted, it is merely necessary to fuse the resulting spongy silver in order to obtain it in a convenient condition for use in making a fresh supply of nitrate, while the whole of the bromine takes the form of zinc bromide, and remains in solution.

(*u*) Those who are familiar with gelatine dry plates must be aware of the large amount of undeveloped silver bromide film there is left on the plate after the development of the exposed image. For the purpose of dissolving the unused silver bromide and clearing the negative, it is immersed in a bath of soda hyposulphite. The bath, in the course of time, naturally becomes highly charged with the dissolved silver bromide, and many processes have been devised for recovering the waste silver therefrom.

One of the most simple is to pour into the hypo bath a saturated solution of potash sulphide, which immediately throws down the silver in the form of a black, flaky precipitate.

The principal objection to this process is the disagreeable smell of sulphuretted hydrogen gas given off, which is especially annoying when large quantities are used. The gas also does damage by injuring chemicals, sensitive plates, and paper within its reach. Dr. Legrange, a German chemist, recommended the use of a solution of ferrous oxalate, but as this is expensive its use has not become general. Dr. F. Stolz, editor of the *Wochenblatt*, followed out Legrange's idea by suggesting the use of the waste ferrous oxalate or pyro developer for precipitating the silver; a plan which is of practical use to the photographer and amateur. The precipitation of the silver is slower by this process than with the potash sulphide, but it possesses the advantage of utilising the waste developer, which is usually thrown down the sink.

After the old hypo bath has been poured into a stone jar or any old vessel, the waste developer is mixed with it from time to time after it is used. Repeated pourings of the developer will, after a time, precipitate all the silver.

When all the silver has been apparently thrown down, a little of the clear liquid at the top is taken out in a test tube and tested with a solution of potash sulphide; if no precipitate occurs, all the clear liquid above the precipitate in the bottom of the jar may be decanted off, and the next saturated solution of old hypo may be poured in and treated with the waste developer.

(*v*) The following is the course we advise for the adoption of the user of dry plates on a moderate scale, who is not averse to the reduction of his expenses by saving his silver waste:—Obtain a two-gallon glass jar having a loosely fitting cover, and about 4 in. from the bottom drill a hole in the side. This hole is then fitted with a wooden plug, or, what is better, a small tap, which is retained in place by a screwed nut, aided by rubber washers. This jar is placed on a shelf in a garden or outside of a window; at any rate, in some place with which there is direct open-air communication. This is rendered necessary on account of the offensive smell emitted at a subsequent stage. Into this the waste fixing solutions are poured, and when the jar is nearly full, a small portion of a solution of potassium sulphide (sulphuret of potash or liver of sulphur) is poured in and mixed with the solution by stirring with a wooden or glass slab. Instantly there is a dense deposition of silver sulphide in the form of a dark mass. Precisely how much of the sulphuret ought to be added can be determined only by experiment. After the precipitate descends a little, if the addition of two or three drops of the sulphuret is not seen to produce a further precipitate, then enough has been added; but if this addition causes further blackness, it must be continued until all the silver is found to be converted into sulphide. It is advisable that no more be added than suffices to effect this end. Owing to the slowness with which the precipitation takes place, it may, in many cases, be expedient to have in use two such jars as that described. After the precipitate has settled down to below the level of the hole or tap in the side of the jar, the supernatant liquid must be run off through this aperture. Upon replacing the plug, water may be added to wash the silver sulphide which is insoluble in water. In this case the deposition will take place more quickly than before. Having obtained the silver sulphide as a dark pasty mass, it can either be placed in the hands of a professional metallurgist or reducer, who will most willingly either purchase it at full value, or fuse it into a button of metallic silver; or, secondly, it can be converted into silver nitrate by the addition of nitric acid, in which it readily dissolves; or, thirdly, it may be mixed with a flux composed of soda carbonate, 7 oz.; potash carbonate, 7 oz.; potash nitrate 2 oz. Mixing this with the silver in equal proportions, placing in a crucible, and then fusing in a furnace, this gives a button of pure silver. The silver nitrate obtained by the second operation is not sufficiently pure for some purposes, but, of course, it may be easily purified. The following is a pretty experiment, and one which is also useful, inasmuch as it reduces the sulphide very quickly. Having cut a hollow in a block of wood, place in it a mixture composed as follows:—Sulphur, 2 parts; nitre, 4 parts; fine sawdust, 2 parts; with an equal volume of silver sulphide. Apply a lighted match to this, and deflagration will take place with great rapidity, and at the close, in a few seconds, the silver will be found at the bottom of the cavity as a beautiful white lump of shining metal.—('Photo Times.')

Silver from Cyanide Plating Solutions, etc.—The baths may be evaporated to dryness, the residue mixed with a small quantity of calcined soda and potassium cyanide and fused in a crucible, whereby metallic silver is formed, which, when the heat is sufficiently increased, will be found as a button upon the bottom of the crucible; or if it is not desirable to heat to the melting point of silver, the fritted mass is dissolved in hot water, and the solution containing the soda and cyanide quickly filtered off from the metallic silver. The evaporation of large quantities of fluid is, to be sure, inconvenient, and requires considerable time, but the reducing process above described is without doubt the most simple and least injurious.

According to the *wet method* the bath is strongly acidulated with hydrochloric acid, observing the precaution to provide for the effectual carrying off of the hydrocyanic acid liberated as given under gold. Remove the precipitated chloride of silver and cyanide of copper by filtration, and after thorough washing, transfer it to a porcelain dish and treat it, with the aid of heat, with hot hydrochloric acid, which will dissolve the cyanide of copper. The resulting chloride of silver is then reduced to the metallic state by mixing it with four times its weight of crystallised carbonate of sodium and half its weight of pulverised charcoal. The whole is made into a homogeneous paste, which is thoroughly dried, and then introduced into a strongly heated crucible. When all the material has been introduced the heat is raised to promote complete fusion and to facilitate the collection of the separate globules of silver into a single button at the bottom of the crucible, where it will be found after cooling.

If granulated silver is wanted, pour the metal in a thin stream, and from a certain height, into a large volume of water.

Desilvering. — According to the nature of the base-metal different methods have to be employed for desilvering. Silvered *iron articles* are treated as anode in a potassium cyanide solution in water (1 : 20), the iron not being brought into solution by potassium cyanide; as cathode suspend in the solution a few silver anodes or a copper-sheet rubbed with an oily rag. The silver precipitates upon the copper-sheet, but does not adhere to it. Articles, the basis of which is *copper*, are best desilvered by immersion in a mixture of equal parts of anhydrous (fuming) sulphuric acid and nitric acid of 40° Bé. This mixture makes the copper passive, it not being attacked, while the silver is dissolved. Care must, however, be had not to introduce any water into the acids, nor to let them stand without being hermetically closed, since by absorbing water from the air they become dilute, and may then exert a dissolving effect upon the copper. The fuming hydrochloric acid may also be heated and 150 parts of crystallised nitrate of soda be added instead of the nitric acid. In this hot acid desilvering proceeds more quickly than in the cold acid mixture, but the latter acts more uniformly. Desilvering is complete when the articles, on being pickled, show no stains.

Tin.—(*a*) The tin-clippings are put into a drum, consisting of stout copper-sheeting, and provided with holes ⅜ in. diameter and 2 in. apart. It holds about 1000 lb. of clippings. It is first made to rotate in an acid bath, in which the tin is separated from the iron: then, by means of a crane, it is lifted into a water-bath, thence into a potash chlorate bath, and, finally, once more into a water-bath. In the first bath the drum rotates, according to the quantity of free acid, 5–50 minutes; in the others, which are only intended to wash away the acid, 5 minutes in each. The work of filling and passing the drum through the four baths, and emptying it, takes 70 minutes, and as a drum holds 1000 lb., 4½ tons of tin waste may easily be worked up in a working day of 10 hours.

In the acid bath about 5 per cent. of iron is dissolved beside the tin. This solution having been passed into suitable vessels, the lead is first separated, whereupon, by the insertion of zinc plates, pure tin is precipitated. The latter is obtained partly in well developed crystals, but mostly in a flocculent state. After having been well washed in water, it can be melted in an iron vessel, and cast in blocks for sale. Since, by the precipitation of the tin, zinc is dissolved (one part of zinc precipitates about two parts of tin), there is finally obtained a solution of zinc and sulphate of iron, which may be used for preserving wood from rot, for disinfecting, or in the preparation of various paints. The waste freed from tin is packed into casks, and sent to iron-works. (A. Otto.)

(*b*) It is not possible to obtain a complete separation of the iron and tin by proceeding according to the various methods which depend upon bringing the scrap to the melting-point of tin, which is then removed in the molten state by mechanical means, such as revolving the scrap in a drum with sand, or by use of a centrifugal machine. The iron which is left contains so much tin as to be of little value for working up in the furnace. The salts of tin obtained by treating the scrap with acid solvents are also too much contaminated with iron to render an acid extraction process advisable. Better results, however, should be obtained with Reinecker's process, which depends upon the power which caustic alkali has of dissolving tin when an oxidising agent is present. According to this process, the scrap is cut up into small fragments, treated in revolving drums with caustic soda for the removal of grease, and thence transferred to other drums, to be acted upon by a solution of lead oxide in caustic soda. The reaction which occurs may be expressed by the equation: $Sn + 2NaOH + 2PbO = Na_2SnO_3 + 2Pb + H_2O$, and since, to a great extent, this is prevented from taking place by atmospheric carbonic acid, Reinecker has devised a suitable apparatus for the purpose. The lye containing soda stannate is separated from the finely divided lead, the former to be worked up in the most convenient manner, the latter to be oxidised and employed in subsequent operations. (Dr. Czimatis).

(*c*) Owing to the vast accumulation of tin scrap in canister, button, and other manufactories where tinned iron plate is extensively employed, considerable attention has been devoted to the utilisation of the same, chiefly with a view to the recovery of the tin, either in the metallic form or that of one of the various salts of tin used in commerce.

It would be interesting and amusing, although not instructive to an equal degree, to glance at the various methods, patent or otherwise, which have been suggested from time to time to effect this purpose. The separate actions of acids, alkalies, and chlorine gas have been utilised; friction and fusion have been resorted to; and more recently electricity has been pressed into service.

Of these methods I am only aware of three which have been employed on any large scale, viz. dissolving in a mixture of hydrochloric and nitric acids, and subsequent precipitation of tin by metallic zinc; treatment with caustic soda and litharge, forming soda stannate; and the formation of tin tetrachloride by the action of dry chlorine gas.

The last-named process is worthy of special mention, and is due to Prof. Lunge. The following is a summary of the details of the process:—

The cuttings with which we had to deal varied considerably in value. Some of the thicker ones contained little more than 3 per cent. of tin, while some of the thinner kinds contained 8–9 per cent. I considered 5 per cent. as about an average. The quantity obtainable was calculated at about 6 tons per week, and the plant was designed to accommodate that quantity, charging twice a day. The iron was designed to be converted into sulphate, a large quantity of which could be disposed of at a high price; the remainder was to be converted into "iron mordant"; the tin was to be converted into stannous chloride, and other salts of tin employed as mordants, and largely used by the dyers of that neighbourhood.

Arrangement of Baths.—The best plan was evidently to make the resistance of each bath as little as possible, consistent with facility of working, and then to arrange them parallel, or in series, or both, so as to include the resistance mentioned above. Eight baths were decided upon. These were made of wood, lined with rubber, and each had the following internal dimensions. Length 150 cm., breadth 70 cm., depth 100 cm. The thickness of the wood was 5 cm., that of the rubber 3–4 mm. Each four baths were formed by the division of one large tank, 3 m. by 1½ m., and the two tanks were firmly secured by iron bolts running from side to side. Placed longitudinally, they occupied exactly the breadth of the building, and they were fixed at the end of the same, at an elevation of one metre from the ground. In front was a platform, at one side of which was a door for the admission of the cuttings, after being washed and packed. The dynamo was situated in the engine room just behind the baths, and communication was made by two copper cables passing through a hole in the wall. At either side wall, and on a level with the baths, was a dissolving tank capable of accommodating half the cuttings after the removal of the tin. A little farther on, and nearly on a level with the ground, were the evaporating down tanks. The crystallising tanks were situated beneath the ground level, so that the solution could be run off from one stage to another without any pumping arrangement.

Anodes.—The anodes were composed of the tin scrap. Baskets were obtained to pack the cuttings in. These, at first, were made of wicker-work, but as they were too flexible, and soon rotted by the action of the acid, their place was supplied by strong wooden baskets, whose sides were formed of stout upright wooden bars, 2 cm. thick, with spaces between them sufficient to allow the solution to circulate freely, while preventing the exit of the scrap. The internal dimensions of the baskets were: Length, 120 cm.; breadth, 30 cm.; depth, 85 cm. Great care was required in packing the scrap, because, if it were packed too closely, the metallic surfaces thereby united, and preventing the circulation of the electrolyte between them, necessarily retained their coating of tin. These baskets held 60–70 kilo. of the scrap, the eight being capable of accommodating about half the total quantity required. Long and narrow strips of the same material were employed to complete the communication with the conductor. As the resistance of iron to the current is comparatively great, a large number of these were required to prevent excessive heating. At one end they were soldered together, and connected with the copper conductor by means of binding screws; the other extremities were distributed throughout the scrap.

Cathodes.—Copper plates were employed as cathodes. These had a thickness of 1½ mm., were 120 cm. long, and 95 cm. in breadth. There were 16 in all, two for each bath, placed one on either side of the baskets. To keep these thin plates of copper as plane as possible, each was surrounded by a framework of copper rod of square section. They were coated with tin to prevent corrosion, as well as to avoid solution by any accidental reversal of the current. These plates rested in grooves at the sides of the tanks, placed at a distance of 10 cm. from the sides of the baskets. They were provided, as also were the baskets, with rubber rollers extending to the sides of the baths, enabling them to be raised out of the same with ease, and without injury to the rubber coating.

Electrolyte.—Dilute sulphuric acid formed the electrolyte. This was employed, not only on account of its comparatively small resistance to the current, but also because it was convenient to turn the solution into the iron sulphate tanks, as soon as it became saturated with that salt, and all the tin had been precipitated from it. Commercial acid of 60° B. was diluted with 9 volumes of water.

Above the tanks was a pulley arrangement for raising the baskets and plates out of the baths as required; there was also an arrangement of levers and eccentrics constructed, whereby the baskets were kept in gentle motion in the baths, thus exciting circulation in the liquid, and tending to prevent polarisation. The horizontal axis upon which the eccentrics were disposed made about two revolutions per minute, thereby raising the baskets a distance of about 5 cm. Levers were fulcrumed into the wall; these passed over the eccentrics, and at their extremities ropes were fixed communicating with the baskets.

The current was conducted by thick copper wires of several plies. Although already coated, they were enclosed in rubber tubing as an additional protection.

The arrangement of the plant having been detailed, it remains to give the results of the working of the same. The baths were first arranged in *series*. The connections being complete a current of 240 ampères at 15 volts was passed through the plant, this proving to be the most economical condition of working.

The tin deposited was at first of a spongy nature, owing to the great acidity of the bath. Soon, however, it began to be precipitated in a more dense, extremely fine, granular, and partially crystalline state, which indeed was preferable, as it fell to the bottom of the bath, and was not in danger of forming a communication with the anode. I will not say that the tin was "chemically pure," but it was purer than commercial tin, and, when thoroughly washed, contained no trace of iron. It fused readily, and almost completely, and that without any addition, provided it had previously been thoroughly washed and dried. The rapidity with which it dissolved in hydrochloric acid was not to be compared to the slow action of that liquid upon granulated tin, and this rendered it peculiarly suitable for the production of stannous chloride.

From the data already given, the theoretical amount of tin deposited can readily be calculated. The electro-chemical equivalent of tin as a dyad, compared with silver is $\frac{117 \cdot 8 \div 2}{107 \cdot 66} = 0 \cdot 546$, and this is equivalent to the precipitation of $67 \cdot 65 \times 0 \cdot 546 = 36 \cdot 94$ mgm. of tin per minute per ampère. For 240 ampères, working through 8 baths arranged in series, we obtain a total precipitate of $\frac{36 \cdot 94 \times 240 \times 8 \times 60}{1,000,000} = 4 \cdot 25$ kilo. per hour. As a matter of fact, little more than half this quantity was obtained, the discrepancy being due to part of the current being absorbed in dissolving the iron as well as the tin, as soon as the former began to get bare. This, together with the natural solution of the iron in the acid, led to the rapid accumulation of sulphate of iron in the baths. The acid here employed took about seven weeks to become saturated. On analysis, the baths were found to vary in a very remarkable manner, first one and then another containing the largest quantity of iron. The tin, on the contrary, remained very constant in amount, both in the individual baths and in the total, the average being 1·5 grm. per litre. Pure tin was deposited until the acid was saturated and no more tin was present in solution; then iron hydrate began to form. This might be avoided for a time by the addition of more acid, but it was better to run the liquid into the "green vitriol" tanks, and add fresh solution. It was not at all necessary to continue the action of the current until all the tin had been removed; in fact after a certain time the action on the iron was even stronger than on the tin. It was found in practice that after the passage of the current, for the space of 5–6 hours, the quantity of scrap referred to was sufficiently free from tin to be dissolved in the iron sulphate tanks with the greatest ease; the tin remaining unacted upon in the presence of the large excess of iron always provided for, and it was not difficult to recover that tin, and utilise it with the rest.

In addition to the consideration of economy, this method possesses advantages which are well worthy of attention, especially where iron sulphate and "iron mordant" are marketable products. As has been observed, the tin is precipitated in a pure form, and in a state of fine division. It may, therefore, be either fused and sold in the metallic form, or it may be converted into stannous chloride, or other salts, for which it is exceedingly well suited, owing to the ease with which it is dissolved. In the process in which the scrap is acted on by chlorine gas, no choice exists as to the form in which the tin shall be sent to the market, tetrachloride being the constant product. The same remark applies to the method where caustic soda and litharge are employed, and in other respects this latter method has little to recommend it, judging from my own observations. The other process which I mentioned is also unsatisfactory. In employing a mixture of hydrochloric and nitric acids, considerably more iron than tin is dissolved, and when the tin is precipitated by metallic zinc, the contamination of the iron chloride with zinc chloride renders it of little value. I do not claim perfection for the method I have advocated. It is capable, however, of considerable modification. A better electrolyte could doubtless be found; probably a solution of stannous sulphate would be the best. I think, however, I have proved that this process is practical, simple, and economical, and further that it presents the additional advantages of purity of product and variety of utilisation, thus rendering it well worthy of a wider application.

The cost of the tin scrap at the locality spoken of was only 2 francs per ton. (Dr. J. A. Smith).

(*d*) Tin plate waste is treated with dilute chlorine at a temperature above the boiling point of chloride of tin, so that the latter immediately after its formation is carried away in the form of vapour, as, if it remains in the form of a fluid in contact with the residues, it gives rise to the formation of chloride of iron, chloride of tin being reduced. The vapours of chloride of tin are precipitated by steam or by contact with moist surfaces in roomy condensing chambers, or are absorbed by chloride of tin solution of medium concentration.

(*e*) Bring the tin plate waste into contact with sulphur in a boiling-hot solution of sodium sulphide, whereby the iron is completely freed from tin. The waste thus freed from tin is thoroughly washed and dried, heated to a welding heat in tubes of rolled-iron, taken out and hammered into rod-iron. The solution of sodium sulphide holding the tin is evaporated, the residue calcined in a reverberatory furnace and the calcined mass reduced to tin, at a raised heat, by means of a mixture of small coal, charcoal and calcined soda or burnt lime.

Lead from Zinc.—Melt the alloy. The specifically heavier lead collects in the lower portion of the crucible, while the lighter zinc stands above it and can be poured off.

Nickel.—For the utilisation of waste from rolled and cast-nickel anodes and of the nickel sand gradually collecting upon the bottom of the vats, the following method is recommended: Wash the waste repeatedly in clean hot water, and then boil in dilute sulphuric acid (1 part acid to 4 water) until water poured upon the waste is no longer clouded by it. Then pour off the liquid and treat the waste or sand with concentrated nitric acid. This must be done very carefully, and a large porcelain vessel should be used to prevent the solution from running over. When the solution is sufficiently concentrated, so that it contains little free acid, it should be filtered and slowly evaporated to dryness over the water bath. The product is nickel nitrate. The nickel nitrate thus obtained is dissolved in hot distilled water, and the solution precipitated with caustic soda carefully and gradually added. The precipitate of hydrated nickel oxide is then carefully filtered and washed, then treated with dilute sulphuric acid with the aid of heat until solution has taken place. The solution is concentrated by evaporation and an excess of concentrated solution of ammonium sulphate is added. The precipitate is the double sulphate of nickel and ammonium, or Adams' nickel-plating salt, which is commonly used for nickel-plating.

Nickel from Old Solutions.—Urquhart proposes the following plan: Make a saturated solution of ammonium sulphate in warm water, and add to it the old nickel-plating solution, with constant stirring, and, after the lapse of a few minutes, a granular precipitate of the double sulphate of nickel will begin to separate. The addition of ammonium sulphate should be from time to time continued, until the liquid is colourless. The precipitated salt is very pure, and may be used directly in making a new bath.

Using up Old Tin Cans.—The following are some of the processes adopted in dealing with old tin cans in a factory near New York.

The principal products of this establishment, which is a foundry, are window-sash weights, elevator weights, and ballast for boats. The weight castings are very hard and, when struck with a hammer, ring like steel. About the only tool which can be used for removing sprues and fins is the hammer, as a cold chisel or file will not stand up to the work. The fracture of the round sash weights is smooth, and shows crystals radiating from the centre like spokes of a wheel.

After delivery at the foundry the cans are first piled upon a large iron grating, located under a sheet-iron hood which terminates in a smokestack. They are sprinkled liberally with crude oil which is set on fire. This process consumes the labels, loosens the dirt and melts the solder, which falls through the grating, is collected, washed and melted, cast into ingots and sold to be used again.

Some of the cans, which have simply lapped and soldered joints, melt apart completely; these are sorted out and the sheets forming the shell are straightened and bound into bundles to be sold to trunk makers, who utilise them for protecting the corners of Saratoga trunks. They are also bought by button manufacturers, who stamp from them the discs used in cloth-covered buttons.

The remainder of the cans, being machine made, do not come apart. These are loaded into large carts, taken to the charging floor on an elevator, and dumped into the cupola. The cupola is fed with coke and cans in alternation. There is occasionally an old wash-boiler or a bundle of tin roofing used, but cans form the bulk of the material. The cans are so light that some of them are carried out at the top of the stack by the force of the blast, and a large screen has been arranged to prevent the pieces from falling on the roof.

WATER GAUGES.

KLINGER'S water-gauge consists of a metallic casing capable of standing high pressures, the A type for low-pressure boilers up to 90 lb., being tested up to 300 lb. steam, and the B type for higher pressure boilers being similarly tested to 500 lb. steam; the arrangement, see Fig 295, consists in the first place of a gun-metal frame, having ends corresponding in size and shape to the ordinary gauge-glass, and which can be fixed on to any existing boiler mounting (Fig. 296). Into this casing is inserted an observation glass, ½ to ⅝ in. in thickness, the glass being specially hardened so as not to break, even under changes of temperature of the most sudden character, and to be capable of resisting a very high pressure, The back of this glass is of prismatic form, with the result that the water-

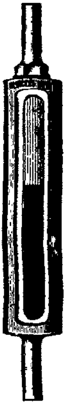

FIG. 295.

FIG. 296.

level is very distinctly marked, owing to the fact that glass and water have not greatly differing indices of refraction for light, while that of steam differs much from either. Hence light entering the gauge above the water level undergoes the total reflection against the prismatic back of the glass, which here shows up like silver; while below the light passes on through the glass into the water, and this portion, therefore, shows up dark. So great is the contrast thus obtained that the water level can be seen even at a distance of 30 yd. from the gauge. By this means a quick and reliable observation can be made of the water level, minimising the risk of explosions and accidents such as before referred to, as well as enabling the man in charge of the boiler to keep always a steady water level, which greatly increases the life of a boiler, while the construction of the metallic casing in which the gauge-glass is inserted renders superfluous any further protecting devices, such as wire netting, etc., and the glasses not being liable to breakage, the expense of replacing them is saved. The Reflex Water Gauge is also made complete (Fig. 297), fitted with best asbestos-packed cocks. This gauge has the same improvements as the attachable gauge described above, with the further advantages of doing away with stuffing-boxes altogether, and giving the longest possible water range.

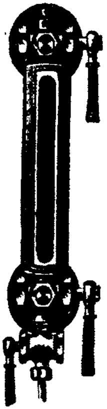

FIG. 297.

It should be particularly pointed out that the distinctness of the indications of the gauge does not depend on luminous paint or similar expedients, but that the contrast of black and white colour is obtained by means of the glass itself, which, as before stated, is shaped prismatically, so as to allow the rays to penetrate in one place, and reflect in the other, an adaptation of a scientific fact which is most effectual.

WATER SOFTENING

FOR COMMERCIAL AND DOMESTIC PURPOSES.

(*See also* BOILER INCRUSTATION).

IT will be understood that any process that may be adopted to "soften" water is intended to remove lime, which is held in solution, and which gives water the property of "hardness."

Hard water prevails, with few exceptions, throughout the southern half of England, and in many districts in the north. In all cases, the hardness is due to the presence of lime or magnesia, or both, and as they are in solution, no filtering process can be successful in removing these mineral impurities.

The hardness of water is of two kinds, temporary and permanent. The former owes its name to the fact that the lime is precipitated and the water softened when it is heated and boiled. With the so-called permanent hardness, the lime cannot be precipitated nor the water softened by boiling. It is the temporary form of hardness that comes to most common notice, as it accounts for the incrusted deposit, or "fur," which appears in kettles, boilers, pipes, or any vessels in which hard water is boiled or circulated.

Limestone or chalk (carbonate of lime), which may be said to have a composition of one atom of lime combined with one of carbonic acid, is an insoluble substance (or but very sparingly soluble), yet by doubling the amount of carbonic-acid gas, making it bicarbonate of lime, it becomes highly soluble. Notwithstanding this, the extra volume of carbonic acid is very loosely held, as the mere boiling of the water drives it off and causes the solid carbonate to appear and collect as a hard deposit-scale, or fur, as it is called.

There are two distinct advantages to be gained by softening water. The first is the prevention of lime deposit in vessels and boilers in which water is heated; the other is that less soap is required and better results are obtained in any washing process. It is the "temporary" hardness only that accounts for the lime deposit when water is heated, and were the hardness confined to the permanent kind no softening process would be needed for boiler-water. In wasting soap, the hardness of both kinds is effective, the action being, roughly speaking, the conversion of a certain quantity of the soluble washing soap into an insoluble lime soap, this appearing as a curd or scum on the water.

It is calculated that 1·2 lb. of soap is necessarily wasted in the use of each 1000 gal. of water, for each degree of hardness. London waters vary in the amount of lime they carry, but the average is 16° (16 gr. per gal.), therefore this gives 19 lb. of soap per 1000 gal. used for washing clothes, a quantity that may be used each month in a country residence and each day in a small laundry. In country residences, however, the hardness commonly exceeds 16°, well-water often reaching 30° to 35°. Some, if not all, of the London waters would be harder than they are but for the fact that they are partially softened before they enter the reservoirs or mains.

There are several water-softening plants or installations suited for domestic uses on the market. With some of these the ingredient used for softening bears a fancy name, while in others the makers plainly state that lime only, or lime and soda are the materials used. It is possible that the fancy-named ingredients may have some other substances mixed in them, but, so far as is generally known, lime (paradoxical though it seems) is the material chiefly used to remove lime from water. The discovery of this fact was made and patented by a Dr. Clark, and in general application it is still commonly spoken of as Clark's process. There have been several improvements made, chiefly with a view of facilitating the removal of the precipitated lime.

As previously explained, the hardness of water is due to lime which is in solution, its existence in this state being caused by an extra volume of carbonic acid. If a substance is introduced that will take this extra volume of carbonic acid, the bicarbonate will be changed to carbonate of lime and be precipitated as a solid substance. Ordinary lime (oxide of calcium), which has an affinity for carbonic acid, will do this; and, made into a cream with water and mixed in proper proportion, a precipitate will follow. Put in chemical terms the reaction is as follows:—

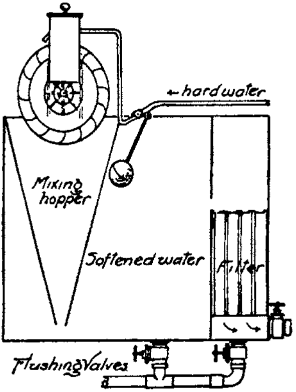

FIG. 298.

$$CaO, 2(CO_2) + CaO = 2(CaO, CO_2);$$

or, 1 molecule of bicarbonate of lime + 1 molecule of lime become 2 molecules of carbonate of lime.

Or, by mixing two forms of soluble lime we obtain one form of insoluble lime, which settles down to the bottom of the softening-tank.

The permanent form of hardness is also due to lime,* but instead of a bicarbonate it appears as a sulphate (plaster of Paris), which does not become precipitated when the water is boiled. To deal with this, carbonate of soda (ordinary washing soda) is used, the effect of this being to convert the sulphate of lime into the insoluble carbonate of lime already described.

The cost of softening water in residences, omitting the labour, which may be that of a domestic servant, and omitting interest on outlay, is from 1*d.* to 3*d.* per 1000 gal., according to the size of the apparatus installed, and the hardness of the water.

The chief details of Maignen's water-softening apparatus are given in Fig. 298. With this the softening material used is the maker's "Anti-calcaire," and the apparatus being automatic in action, it is stated only to require the upper hopper to be filled once a week (or at longer intervals), while the settling tank and filter only need flushing out once in three months. There is nothing about the plant to make the softening of water troublesome or difficult in a house where an intelligent lad or gardener is employed. The material, "Anti-calcaire," acts on both the bicarbonate and the sulphate of lime to throw them out of solution. This apparatus, to work automatically, requires to be served by a water company's main, or a storage cistern. In towns the former would apply, but with isolated houses which rely on private wells, the daily supply would need to be pumped up into a cistern above the level of the softening plant. From this cistern the water flows through the ball-valve shown.

There is now the question of the saving effected by soft water, as compared with hard, when heated in boilers. Confined as this article is to comparatively small requirements, the question of boilers must be confined to that of the kitchen range—the bath or circulating boiler. No fixed rule or table can possibly be suggested, but in moderately busy houses, using water of normal hardness, say 16°, the range-boiler has to be cleaned out twice yearly. By cleaning out is meant, of course, the removal of lime deposit or fur. The average charge for this is 10*s*. for each occasion, or 1*l*. per annum. An additional expense, incurred by the lime, is that more fuel has to be burned than is needed with a clean boiler to heat a given quantity of water. In the average of houses the deposit of lime in 6 months is ¼ in. thick, a mean thickness of ⅛ in. for the whole period. Limestone is a poor conductor of heat —17 times worse than the iron of the boiler—and the retardation of heating due to this cause is serious, and at a low estimate the lime deposit increases the consumption of fuel, for given results, by from one-fourth to one-third. This probably means 20 to 30 lb. of coal extra per day in most houses of good size, say 3 tons per annum.

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* It should be mentioned that magnesia is commonly present with the lime, and is productive of hardness, but the softenin treatment removes this.

Next there is the wear of the boiler. In the typical house under consideration, the plate of a range-boiler will usually be burned through in 2 years, if the lime deposit is not regularly removed. It cannot be supposed, however, that it is destroyed to the extent of one-fourth in the first 6 months (assuming it is cleaned every half-year), but that it has received a certain amount of injury due to the lime there can be no doubt. The injury per annum may be valued at 1*l*., or less, but that it is a real one is certain. It will be seen, therefore, that the softening of water for domestic uses is a good thing in the most practical sense, both in the saving effected in meeting the hot-water demand, and in the saving of soap. In addition, every housewife well knows that soft water serves many purposes in a greatly superior manner to hard water. This is why the rainwater tub or tank exists as an adjunct to so many homes that are served by hard water.

WATER SUPPLIES TO ISOLATED COUNTRY HOUSES.

(*See also* FILTERING, HYDRAULIC-RAMS, PUMPS, ETC.)

THE important points to be considered are as follows:—Quantity of water that should be provided per person; means of collection and storage, and the qualities of the water, and the possibility of it being contaminated at any point.

The quantity of water usually allowed each person in a private household is twenty-five gallons, this sufficing for ablution, including bath, cooking and general servants' use, water-closets, and clothes washing. In allowing this quantity per head, all servants and employees are counted. Assuming that there are stables, the men in charge and the horses should be counted in, as much water will be used. This is supposing the house cisterns are drawn upon for everything; but if separate wells or supplies are used for stables and laundry, then, of course, they need not enter into the present calculations. In country house work, where the water is only obtained by manual or mechanical labour, the minimum of water is allowed per head as a rule, but, for general purposes, twenty-five gallons should be considered the least practical quantity, and thirty gallons are undoubtedly better.

In many places well water is not relied on to any extent, but the whole supply is rain water, collected in underground tanks. In country places the contamination of rain water by organic matters in the air need scarcely be considered, but the impurities it may come in contact with, after reaching the earth, require every attention. Where a pond or small lake is relied on, then it is very necessary that cattle be kept from the land near it, or the rain water which drains into the lake will be polluted. From this point there is usually a supply taken which goes to fill an underground storage tank, either by gravity or by the aid of a pump, but between these points the water should undergo sand filtration to remove suspended matters. (*See* FILTRATION.)

With roofs which are slated, there is no reason why the rain falling on the surfaces should not be collected and stored; and houses of good size, compared to the number of inmates, have a roof area capable of yielding all the water that is required. A slated roof yields water with the least impurities; but tiled roofs, unless periodically freed from moss and dirt, are not good. As a fall of rain is very uncertain as to its occurrence, and as to quantity, it is proper to provide underground storage capacity for at least one-fourth of a year's supply.

To calculate the rainfall ascertain the average for the district, this information being usually readily obtainable whatever the rainfall may be per annum, though it must not be supposed that the whole can be collected. Showers often make no more than a little moisture in a gutter; and with moderate falls much of the water is evaporated. With "separators," (*see* RAIN-WATER SEPARATORS) which should always be used for this work, at least a fourth of that available runs to waste, so that little more than half a year's recorded rainfall can be relied on for storage. To arrive at the quantity that can be collected in this way, the flat plan of the roof is measured (not making any allowance for slope of roofs), and this area can be multiplied by half the rainfall in inches, which will give the result in gallons. Thus, a roof of 2000 ft. area multiplied by 12½ (being half a 25-in. fall) will yield 25,000 gallons, and this will be the full total yield, without any allowance for loss, evaporation or other means. Consequently this should be halved to find the amount that can be stored with certainty; or if the area is first multiplied by one-fourth of the rainfall in inches the same figure will be obtained.

The "separators" alluded to and described on another page are ingenious devices by which the first washings of the roof by rain are diverted into the drain or to any desired point, for this first water will carry dust, insects, birds' excreta and other such objectionable materials with it. After a certain amount has passed a movement occurs in the appliance, which then directs the water into the storage cistern. Without a separator, roof-water should not be used except after first passing it through strainers and sand filters, for it will be understood that a roof, after two or three weeks' dry weather, collects many objectionable matters which a storm thoroughly removes and carries into the down pipe.

In making underground tanks there should be an overflow provided (carefully trapped and disconnected), also air inlet and ventilating outlet. The overflow is to provide against possible upheaval of the ground over the tank, as a heavy storm, when the tank is already nearly full, will tax its capabilities. The tanks are brick built, puddled outside, and well trowelled in cement on the interior. This is necessary, not only to prevent loss of water, but to stop possible ingress of surface water, containing impurities from cesspools, etc. It should be made a watertight tank, with convenience for occasional cleaning, and the overflow, as previously mentioned, must be carefully protected from foul odours, vermin, etc. Means of calculating capacities of tanks will follow, but it may be mentioned here that it is only requisite to multiply the length, the width, and the depth, and this by 6¼, to obtain the holding capacity in gallons: thus a tank 20 ft. by 10 ft. by 5 ft. deep has 1000 cub. ft., and this multiplied by 6¼ gives 6250 gal. (a cubic foot of water is 6¼ gal. very nearly).

If desirable, a separate storage tank can be provided for washing purposes in stables and laundries and similar use, the catchment area not necessarily being the roofs, but any hard clean surface of yards, etc., which are not fouled by animals. This water, however, should not be used for drinking or cooking, neither should there be any possibility of it becoming mixed or being drawn with that used in the house. It is best to have storage tanks divided, or in very large houses to have several, that one part can be emptied and cleaned without discharging the whole of the water in store, and the cleaning should be done during the season that water is generally most plentiful.

The water of streams and small rivers is largely rain-water, when rain occurs, but at other times it may possibly be spring water, which, as a rule, is very wholesome. Spring waters have inorganic impurities, but this latter word creates a wrong impression, as natural inorganic matters in solution with water are not usually objectionable. Lime is one, which goes to make water hard, but this, except in excess, is perhaps more beneficial than otherwise; certainly it is in its effects on iron and lead pipes and cisterns, but this will be spoken of later. The water of springs and rivers have therefore to be treated as rain-water in regard to organic impurities, for unusual care would have to be exercised to prevent the washing of fields, with the excreta of cattle, etc., having a natural drainage to the stream. There is, it will be understood, a natural purifying process going on in all streams by means of plants and other agencies, but with flood and storm waters there is much solid and impure matter carried down. On this account water from these sources must be treated by filtration, but a sand bed or filter is usually sufficient before the water enters the storage tanks.

With regard to well waters, wells are generally considered as deep when exceeding 50 ft. in depth, while a less depth than this is called shallow. It is a wise plan, whenever there is doubt as to the purity of the water to have the water submitted to examination by a competent analyst. When the conditions are normal, shallow well waters are open to suspicion, but deep well waters are usually wholesome and good. Shallow wells would be as free from ill features as deep wells, if it were not for human ingenuity in some form or other. For instance, the water, which is, of course, only subsoil water, may come off cultivated land which has been fertilised with some sort of manure. Then, again, there is the risk of contamination by cesspools, privies, dust-heaps, etc.; and in districts where the subsoil is of an open gravelly nature, no cesspool should be within a distance of less than 200 ft. of the well. The risk depends in a great measure on the quantity of water pumped, for if the pumping is not continued for long periods there is less risk of impure water being brought into the area of that which is pure. In other words, the smaller demand there is at the pump, the less the distance it may be from suspected spots, if distance is an important factor in the question. It should also be mentioned that with country houses there is the likelihood of cattle being pastured on or about the ground where the well is sunk, and if this is not guarded against there is a strong probability of the subsoil water being polluted by this means. It depends to some extent upon the nature of the ground, but it is the best plan to fence the ground off for, say, 200 ft. round the well if cattle are about.

Before proceeding to describe the different machines and appliances for raising water, some particulars as to the composition of water and its action on metals may be given. It was previously mentioned that water often carries inorganic impurities, which, although generally non-injurious to health, have to be considered by the plumber, as do also the effects of water which is without them. This information largely relates to the action of hard and soft waters, that is, water with or without lime in solution. The hardness of water may be temporary or permanent, the former owing its name to the fact that, by boiling, the hardness can be effectually disposed of, while the latter is proof against boiling, and can only be removed by chemical process. The sulphates of lime and magnesia are generally accountable for this so-called permanent hardness, while carbonates of lime and magnesia account for the hardness which is removable by boiling. The effect of boiling is to precipitate these ingredients, causing a stone-like deposit in kettles and boilers which is commonly known as "fur." (*See* KITCHEN BOILERS).

The hardness of water is usually considered objectionable owing to the deposit it creates, and also to the waste of soap it incurs. It is stated that the Kent Water Company's water can cause a waste of 265 lb. of soap for every 10,000 gal. of water, whereas the soft water of Manchester will only waste 32 lb., Glasgow 4 lb., and Lancaster 1 lb., with the same quantity of water. Hard water is not so pleasant to use, at least for washing purposes, but after all objections there are numbers of engineers in the north of England who say that our hard waters of the south are preferable to the soft waters they have there. Soft water is very active in attacking certain metals, particularly iron and lead, and zinc; and when this water has a faint trace of acidity, the action is most marked and destructive.

Wrought-iron pipes do not last long with soft water, and while they are in use the rusting is so great as to make the water quite red, in many cases unfit even for bathing purposes. With lead there is no noticeable discoloration of the water, but the oxidising process is just as strong, and the water is rendered unfit for drinking purposes, being poisonous. Lead poisoning has occurred to serious extents in several districts served with soft water through leaden pipes (or leaden cisterns), and this is the more easily done, as lead is a cumulative poison, collecting in the system when taken repeatedly until sufficient to have an injurious effect.

Zinc has a similar ill effect on the system, not so marked perhaps, but fully enough to classify it as dangerous, so that lead and zinc can seldom be used in districts served with soft waters; nor can galvanised iron, of course, as this is merely iron which has been dipped in molten zinc. Tinned copper, also tin-lined iron and lead pipes, are used in such cases, and prove an expensive remedy, sufficient, as stated, to make the engineers of those districts think well of the harder waters which cause none of this trouble. It is said that in some places the ill effects of soft water on lead pipe have been obviated by the admixture of about five per cent. of tin with the lead of which the pipe is composed, for tin is proof against injury by soft water. It is quite possible to harden water by adding lime to it, if the circumstances make it desirable; but this is not so simple a task as may at first sight appear. Limestone, that is, ordinary chalk or carbonate of lime, is not soluble in water, unless it has an added volume of carbonic acid gas in it. With this gas present (as about to be explained) the water will freely take the lime into solution.

It is the presence of lime in hard water that prevents the destructive action which soft water has on iron, lead and zinc, and in hard-water districts pipes and storage cisterns of these metals are used freely, and give no more trouble than occurs from ordinary wear and tear. The generally accepted explanation of this is that soft water does not attack metals if it carries no carbonic acid gas in it, but as water has a great affinity for this gas, and there is everywhere abundant means for their coming together, they are always very closely associated. When lime is present, however, there is then a material which the acid gas has a still greater affinity for, and in combining with the lime becomes inert as to any destructive combination with the water. The outcome of this is that plain iron pipes seldom give trouble with rust when conveying this hard water, either hot or cold, nor do lead pipes or galvanised cisterns have their surfaces dissolved or eaten away, and the water may be drunk freely.

Hard water is more palatable, and brighter, than that which is soft, and is usually preferred by users except for washing purposes. The waste of soap is, in itself, hardly worth considering, for although it is recorded that a change of water at Glasgow with a reduction of 6½ degrees of hardness made a difference of 36,000*l.* per annum in the consumption of soap, yet this would only save the small sum of two shillings to each inhabitant per year, with presumably a loss of the larger sum to soap manufacturers and those they employed. If it was desirable to make this change, then every effort is desirable to effect it, but as the softer water brings more troubles in its train, the actual gain to the consumer is not so real as it appears.

The majority of the hard waters served by the water companies in the south of England are not so hard as when first collected, for they undergo a softening process by which a proportion of the lime in solution is precipitated before the water enters the service mains. This process is not carried to such an extent as to make the water quite soft, but reduces the hardness to from 10 to 16 degrees, this being 10 to 16 grains of lime per gal. of water. Filtration has practically no effect in removing lime in solution from water, for the lime is in a fluid condition itself, and freely passes through the filtering material; it is only when precipitated by boiling or chemical process that it assumes its solid and visible form. It is considered that hard water is quite suited for general consumption if the hardness does not exceed 16 degrees, and any well or other waters having a greater percentage of lime or chalk than this should be subjected to some softening process.

The process most generally known and approved is Clark's, an ingenious but simple plan by which the addition of a certain proportion of lime has the effect of absorbing the excess carbonic acid of the bicarbonate of lime in solution, and by this means converts the whole into an insoluble material which is immediately precipitated. This can be effected on a small scale, but there are other processes which are, the writer believes, modifications of Clark's, prepared and more suited for domestic requirements. Doulton and Co., and several other firms, make a complete apparatus or plant suited for country houses, arranged so that it may be used by an unskilled person, a gardener, or whoever attends to the water supply of the building. The necessary features of such an apparatus are that there must be provision for mixing the lime in proper proportion, and this, which is in the state of a milk of lime, has to be properly added to the water under treatment. The water is treated in a separate tank, as the precipitated matter must not be allowed to enter the house service pipes; and only after the water has been completely dealt with is it allowed to enter the house cistern. This operation can be regulated to decrease the hardness as desired.

A new softening apparatus, recently given a favourable notice in the *Lancet*, is styled the Lawrence process of softening and sterilising water. This is a boiling process, and waters which have their hardness due to carbonate of lime (as the majority of hard waters have) can be softened by being boiled. Boiled water is soft, but it is also flat and insipid to the verge of being undrinkable, and one object of this process is to revive the water after boiling and make it palatable. It is claimed that the cost of working is very small, with the important advantage that water softened by this means is also sterilised and safe to drink, even if drawn from a doubtful source. The softening can be partial if desired, so as not to leave the water absolutely free from lime, and the makers do not appear to have overlooked that very requisite feature, viz. a simple means of removing the lime that is deposited in the heating chamber. It is stated that this apparatus, which can be worked with gas, oil, or a fire, gives very economical results for the end attained, and this is largely due to the fact that the hot softened water is utilised to heat the new inflowing water, and by this means not only does much towards heating the water which is as yet unboiled, but also is itself cooled.

In regard to raising water from its source, the means are practically limited to two, viz. the hydraulic ram and the pump, but the variety of ways by which pumps may be worked is considerable. Where there is a fall of water to be had, and the water is of suitable quality (being afterwards filtered if necessary), then the ram gives excellent results. It is, of course, automatic in its action, costing nothing for power and little for attention; and as instances are known of rams raising water 800 ft., 200,000 gal. a day, from a distance of two miles, there seems little room to wish for anything more efficient than this. Of course, such results could only be had from very large rams with good falls.

Rams can be had to work with falls (or head of water) varying from a few inches to 30 ft., but the latter should be considered a maximum, and may be reduced with advantage, as the wear and tear would be considerable. The quantity of water that can be raised by a ram and the distance it can raise it are in ratio with the fall, and the quantity of water raised to that wasted is in ratio also. Where the fall of water is but trifling it can usually be augmented by damming the stream, but, of course, every care is necessary to see this does not cause the stream to overflow its banks at any point. When the water supply is insufficient to work a ram continuously, it can be made to work intermittently, that is, to discharge water at intervals, and rest between while the water is collecting. This is usually arranged by a syphon, but an automatic valve can also be had to effect this.

A reliable table to estimate the efficiency of rams from (supposing the rams to be of good make, such as Blake's, Keith's, etc.), and to judge what percentage of work they can do with certain proportions of fall and height of rising main, is as follows ('Thresh'):—

Fall.	Height Raised.	Degree of Efficiency.	Fall.	Height Raised	Degree of Efficiency.
yd.	yd.	per cent.	yd.	yd.	per cent.
1	2	86	1	7	60
1	3	76	1	8	58
1	4	70	1	9	56
1	5	66	1	10	54
1	6	63	1	12	52

Or another way in which the information has been put is as follows:—

10 gal. per min. raises 3000 gal. per day 100 ft. high with fall of 30 ft.

10 gal. per min. raises 2000 gal. per day 100 ft. high with fall of 20 ft.

10 gal. per min. raises 1000 gal. per day 100 ft. high with fall of 10 ft.

10 gal. per min. raises 500 gal. per day 100 ft. high with fall of 5 ft.

A further table, that is also of use in determining the sizes of rams and their connections, is given by Hughes, Sutton and Digby, Ltd.

To obtain a necessary or increased fall the ram can be sunk to any possible extent, provided the waste or tail water can run away. In stormy weather a ram may become submerged to a trifling extent, but this does not prevent its working.

To ascertain what quantity of water a small stream can supply, it can be gauged by fixing a straight thin-edged board across to act as a sill, and all the water must be made to pass over the edge of this board and none underneath. The depth of water on the sill

Diameter of Fall (Injection) Pipe.	Diameter of Delivery (Rising Main) Pipe.	Quantity of Water available to work Ram (in Gallons per Minute).	Approximate Number of Gallons raised in 24 Hours.		
			50 Feet High.	100 Feet High.	200 Feet High.
in.	in				
1	½	1 to 4	200 to 800	100 to 400	50 to 200
1½	—	4 ,, 10	800 ,, 2000	400 ,, 1000	200 ,, 500
2	¾	10 ,, 20	2000 ,, 4000	1000 ,, 2000	500 ,, 1000
2½	1	20 ,, 25	4000 ,, 5000	2000 ,, 2500	1000 ,, 1250
3	1¼	25 ,, 30	5000 ,, 6000	2500 ,, 3000	1250 ,, 1500
3½	1½	30 ,, 40	6000 ,, 8000	3000 ,, 4000	1500 ,, 2000
4	2	40 ,, 60	8000 ,, 12000	4000 ,, 6000	2000 ,, 3000

must then be carefully measured, or perhaps we should say the distance from the edge of the sill board (which is fixed quite level) and the level of the water in the stream above it, and the following will be found to be the number of gallons per hour passing over for every foot width of the sill board. ('Maguire.')

Depth on Sill. Inches.	Gallons per Hour over each Foot Width of Sill Board.
¼	260
³⁄₁₀	300
½	650
1	1900
1½	3600
2	5400

It is, of course, necessary to ascertain whether the quantity of water in the stream fluctuates with the seasons.

The working capacities of Keith's rams are as follows:—

Ram.	Drive Pipe.		Delivery Pipe. Size.	Head of Water above Ram.	Height to Raise Water.	Water Raised in 24 Hours.
	Diam.	Length.				
Size.	in.	yd.	in.	ft.	ft.	gal.
A	1 to 1½	40 to 60	⅜ to ¾	10 to 20	100	300 to 600
B	1¾ ,, 2	50 ,, 75	¾ ,, 1			800 ,, 2000
C	2½ ,, 3	60 ,, 90	1 ,, 2			2000 ,, 4400
D	3½ ,, 4	90 ,, 100	1½ ,, 2½			3000 ,, 9000
E	5 ,, 6	100 ,, 130	2 ,, 3			5000 ,, 13000
F	7 ,, 9	130 ,, 160	2½ ,, 3½ or 4			10000 ,, 25000

The above figures are based on the delivery pipe being from a quarter to one mile long, and it can be calculated that the rams will raise water thirty times higher than the fall which works them, but only good quality rams are capable of doing this.

There is no doubt that, where possible and convenient, the hydraulic ram is an excellent means of raising water for country residence supply, but if a fall of water is available, a water wheel can be recommended as a means of driving a set of pumps. These wheels are of three kinds, viz., the overshot, the breast, and the undershot wheel, the former being the most efficient. Expressed in figures their relative effectiveness, with the same stream of water working them, is 68, 55 and 35 respectively; a hydraulic ram standing at 60 in this scale. Undershot wheels, however, notwithstanding their lower effectiveness, are very useful with poor falls, for they can do work where a ram or a turbine are almost useless. They can, in fact, work without a visible actual fall, the natural flow of a river being utilised.

As a water wheel revolves comparatively slowly, the pumps can be connected and worked from the shaft or axle direct. The only care that is necessary is to fix the pump rigid, and let the crank shaft of the pump and the wheel shaft or axle be perfectly true with each other.

In fixing a wheel there has to be a channel provided to bring the water direct to the wheel, that its force may be expended on the wheel blades to best advantage, and this channel is known as the "wheel race." With overshot wheels the race delivers the water slightly beyond the centre line of the wheel, and as a rule the flow or impetus of the water is not relied on to drive the wheel, but reliance is had on the weight of the water which is continuously delivered into the blade buckets. Consequently when the flow of water is rapid, the end of the race is so constructed that the impetus will not carry the water beyond the wheel, nor splash and only partially fill the buckets. A slow delivery is best, and a slow-moving wheel is usually more powerful than a very fast one. It is largely governed by the proper filling of the blade buckets of the wheel; and a small wheel revolving at about 3 feet per second, and a large one, working at 6 to 8 feet per second, give the best results.

The breast wheel works partially by the weight of water received in its buckets or floats, and partially by impact of the water delivered to it. The race is so arranged that the flowing water may expend its strength as far as possible in driving the wheel, and to effect this the blades are so designed in their relationship with the race that the escaping water is only that which has been deprived of its force in the buckets. Notwithstanding this, however, it is not so efficient as the overshot wheel, and its revolutions, of course, vary more with the flow of the stream.

An undershot wheel, whether driven by a small fall or by the running water of a stream, relies wholly on the impetus of the water, and under most conditions the efficiency of this wheel falls considerably below the others. Every effort is made to utilise the speed movement of the water to the utmost (the reverse of what is aimed at with the overshot wheel), and the blades of the wheel are designed for this purpose.

With the overshot and breast wheels the water which has passed them, and which is known as the "tail race," is made to escape, so that it has no prejudicial effect on the speed of the wheel, not hindering or retarding its movement; and in effecting this it is only necessary to keep the wheel just above the level of the tail water. With an undershot wheel this is not so easily done if there is no pronounced fall of water, and therefore the blades are so shaped that they rise without the tail water holding them or resisting their movement as they ascend.

Another form of water motor is the turbine. These can be had to work with low falls, but very generally a turbine is resorted to when the fall is high. The useful height of fall to work a water wheel is, of course, limited, and the same can be said of a hydraulic ram, with which the wear and tear, with high falls, is too great to admit of its economical use. A turbine is an enclosed wheel which is propelled by an enclosed falling column of water, and it is utilised as an engine for driving a set of pumps (or other machinery). In the "pressure" turbine there is a wheel with suitably curved blades or vanes, and the water is directed to this through a casing which is also fitted with curved blades or guides, so that the water is directed in the most effective manner possible on to the blades of the wheel. This turbine can be fixed horizontally or vertically as may best suit the conditions, and it need not be fixed at the extreme foot of the fall unless desired. When it is fixed a few feet (20 feet is admissible) above the lowest point, then a waste pipe is carried from it, and the fall of the expended water through this will aid the turbine in its work by suction.

Another form of turbine is that in which the falling water, conducted by guides, is caused to act against a series of buckets around the edge of the wheel. This turbine should be fixed at the lowest point of the fall, as a waste or suction pipe does not aid its work to any useful extent. This latter turbine is very effective with high falls. Different makes of turbines vary considerably in efficiency, and in cases where the fall of water has to be economised every care should be exercised to see that the turbine is of good make. With an abundance of fall water a cheap make will answer, though it has usually to be of larger size for given results. For small supplies, under ordinary conditions, the water wheel or the ram are better than the turbine, though the latter has probably no equal in efficacy when the conditions make its use necessary or desirable.

Another cheap source of power is the wind, this being utilised by windmills. These have been perfected to quite a remarkable extent, and in situations where the wind can be utilised to advantage, and where no better or regular source of power is to be had, the wind engine is worthy of every consideration. It is doubtful whether it will be used to any extent for very large supplies, but for mansions, farms and groups of cottages (also for irrigation or draining) the machine is very useful. The modern circular sail or wheel type of wind engine has many improvements by which it will work with a very light pressure of wind, yet in times of storm the sails are self-regulating, so that excessive wind pressure has no serious effect; or with some makes there is a striking gear, by which the blades are quite thrown out of use. The sails also automatically adjust their position to the wind, as its direction varies. The sail is, of course, erected on a wooden or iron lattice tower of a suitable elevation, and the size is governed by the requirements. The spindle or shaft can be connected directly with a crank to which the piston rod of the pump is attached; but the better plan, when a liberal supply of water is needed, is to connect to the gearing of a double or three-throw pump. In this, as with practically all water-raising machines, the makers had best be looked to to decide and guarantee the work that their engines will do. Of course, the buyer should also use his judgment, but independent tables showing what certain sizes of machines will do are not always reliable, and makers' tables vary to a considerable extent. It has been calculated that the average wind power available in England gives 1 lb. pressure per sq. ft. at a speed of 14 miles an hour, for a period of 8 hours per day. With such a breeze an engine with a 10-ft. sail can yield about 1400 to 1600 gal. per day; while a 12-ft. sail can give about one-fifth or even a fourth more. It is important to remember that wind power is very uncertain, particularly in the summer time, when probably the demand for water is greatest. On this account it is necessary to have the engine (and the storage tank) of sufficient size to provide at least 5 or 6 days' supply; and, in the writer's opinion, a wind engine should not be relied on when the daily supply of water required is as much or more than 15,000 to 20,000 gal. In such cases, if other cheap power is not available, a steam, gas, oil or other motor should be used. The wind engine, however, when it can be conveniently used, runs with a minimum of attention, and may be safely recommended; and two or more engines can work to one well if the water supply is sufficient.

Of steam motors, i.e. engines, for pump work there is almost endless variety, and it is scarcely within the province of this book to recommend a few to the exclusion of the many that are worthy. As the majority of engineers who make pumping machinery also make the engines, there should be no hesitation in deciding to obtain the two from one maker. Many, in fact nearly all, make the engines and pumps combined, so as to form one piece of machinery, and the boiler only is separate. In country residence work, however, the steam pump does not figure to any extent unless steam is used for other purposes, and the well is within reasonable distance of the other works that the steam is needed for. Gas, oil and hot-air motors are more largely used, as being more easily erected, also more easily managed subsequently by an unskilled man.

For moderate supplies the hot-air motor has much in its favour, its management being so very simple.

One well-known type, the "Rider" engine, is made in different sizes up to one horse-power, and is sent out fitted complete with lift and force pump, and a quarter horse-power size with 2-in. pump will deliver 500 gal. per hour 40 ft. high. There is no skill needed in working them, it being only necessary to start and stop the engine to replenish the fire (with coke fuel), and see to the lubricators. It is stated that the consumption of coke is only 2½ lb. per hour for a quarter horse-power engine, which represents a cost of about one halfpenny per 1000 gal. of water raised 30 ft. high. This engine, in the larger sizes, can be fitted for deep-well work if required. It is considered absolutely necessary to put a safety valve on the rising main from the pump; and this is particularly the case when the main has a stop-valve in it. When duplicate or branch mains are used, it is commonly arranged that either one or both be controlled or shut off by a stop-valve, and in all such cases the safety valve should be fitted, to avoid trouble and damage should the stop-valves be left closed accidentally. The safety valve must be fitted somewhere between the pump and the stop-cocks.

Probably the most convenient engine for country house work, as requiring the least possible amount of attention, is the gas engine. This is, of course, useless if no gas is obtainable, as is so often the case in country places. Where, however, gas is to be had, it is an engine that only requires starting or stopping, with necessary cleaning and lubricating, and little or nothing else. The writer has fixed these largely in country houses for pumping purposes (and in London residences for electric light), and it is quite exceptional to find any one in the engine house. It seems to be the rule to start the engine, then let it take care of itself until it needs stopping. As a rule these engines can be used for several different works in a house of large size, and cases have been known of an engine having to work a dynamo, run a small bench saw, work the laundry machinery and do what pumping was required; it did not, of course, fulfil all these purposes at once, but there is no reason why the engine should be idle any part of the day when there is work it can do.

It is not desirable to gear a gas engine direct to a pump, a countershaft being generally used.

Oil engines are coming very largely into use as motors for pumps, and can be had capable of raising 1000 gal. of water per hour and upwards, according to the size of the plant

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WATERPROOFING.

See also DAMPNESS IN BUILDINGS.

Waterproofing with India-rubber.—The crude rubber, which is received at rubber works in the condition in which it is imported, varies greatly in appearance and quality, as well as in the amount of impurities it contains, and which must be removed before it can be manufactured.

The preliminary processes, therefore, to which the crude material is subjected, have for their object this cleansing of the rubber from impurities, and at the same time the softening of it, and its reduction to a form in which it is best fitted for subsequent operations. (1) The crude material is introduced into a vat or tank with water, and boiled by throwing in free steam. This operation, which has the effect of softening the crude masses, is sometimes carried on in the open air, but in other works within some part of the building. Some makers find it sufficient to soak the crude rubber in water at a temperature not higher than 120° F. (49° C.). (2) When thus softened, the masses of rubber are passed between powerful rollers, the surfaces of which are indented with flat, square indentations, while a stream or jets of water flow upon the rubber from a perforated pipe above. By this operation the rubber is flattened out into a thin sheet, and more or less torn and disintegrated, while the water works out the foreign substances, dirt and impurities, which the boiling has failed to remove. This process is repeated until the mass is thoroughly cleansed. The result is the production of a thin crumpled sheet, full of holes, which is then hung up in a room warmed by hot air to dry. (3) The rubber thus washed and cleansed is introduced into the "masticator," which consists of a strong cylindrical box, containing a stout deeply-fluted iron drum, which revolves within the box; steam is introduced into the interior of the drum, and a current of water is kept running between the drum and the cylinder. It is then introduced dry into another similar "masticator," the flutings of the drum of which are made sharp and chisel-shaped. The rubber is here torn to pieces, rendered homogeneous, and the last traces of air or water are expelled. At some works this process of "mastication" is omitted. (4) If it be desired to cut up the rubber into sheets, etc., the rubber thus prepared is made into blocks of the requisite size by compression in a strong screw-press iron box, the inside of which is smeared with French chalk to prevent sticking, and the sides of which are hollow and filled with steam. A uniform block is thus obtained, which when cold or frozen can be cut into thin sheets or smaller blocks as may be desired. (5) When it is intended to prepare the rubber for the process of "vulcanisation," the vulcanising material is either kneaded with the rubber in a masticator, or by means of mixing rollers heated by steam and kept for the purpose. In either instance it is in the form of the rough sheets above described that the rubber is introduced, and there is a shallow tray beneath to catch such of the material as falls through. The vulcanising material consists generally of finely-sifted flowers of sulphur, together with colouring powders such as lampblack, zinc oxide, or antimony sulphide (orange). These are thoroughly incorporated with the rubber in the apparatus used. (6) After this stage of preparation, the Goodyear or American process, and the Hancock or English process diverge. (*a*) By the Goodyear process the rubber thus prepared is rolled out into sheets by causing it to pass between strong iron rollers heated by steam, in what is known as the "calendering" machine, and these sheets may be subsequently manipulated for the construction from them of various kinds of articles. As the sheet passes from between the rollers it is received upon linen, and the linen and indiarubber sheets are rolled up together upon a roller. (*b*) In the Hancock process a solvent is used to soften the rubber and convert it into a thick paste. The solution is sometimes effected in a close cylinder, where the rubber and solvent are, by an arrangement provided within the cylinder, wrought up together, and from which the pasty product is drawn off by means of a tap below. The paste is received into iron pots provided with covers, in which pots it can be reduced, by hand mixing with more solvent, to any condition of liquidity that may be desired. In other works the solution is effected in another way. The rubber, calendered out into a thin sheet, is passed between a pair of hot rollers into an open vessel containing solvent, by the side of which vessel a workman sits and presses down the sheet, softened by the heat, into the solvent. When rubber enough has thus been put in the vessel is covered up and set aside for the completion of the solvent action. In other works the rubber is simply mixed with the solvent with a spade. In order to make the thick paste into a sheet, what is termed a "spreading machine" is used. This consists of a table formed of a hollow steam-chest, along, but not touching, which a sheet of linen previously sized is rolled off from a roller at the spreading end to a roller at the farther end, and from this to other rollers underneath. By an arrangement devised for the purpose the softened rubber or thick paste is spread in a thin layer on this linen as it passes to the top of the steam-chest; and the rubber thus laid on is carried upon the linen as if it had been painted on it. As the sheet passes slowly along the top of the steam-chest the heat causes the solvent to volatilise. This operation is repeated until the required thickness of rubber is obtained. It is conducted in a room where many similar machines are in use at the same time. The rubber is then stripped from the linen by rolling each off in different directions upon different rollers, with the aid of water. As the rubber is rolled off, it is evenly coated with a wash of French chalk, to prevent sticking, and the roll being bound round with a wet cloth bandage, is ready for the "vulcaniser."

Spreading.—Reference may now be made to the treatment of fabrics which are to be "waterproofed" by spreading. This consists in passing the fabric through a pair of calenders, with the object of pressing down knots, and giving a smooth and even surface; after this, the fabric is passed over a steam-chest, to expel moisture, when it is ready to receive the first coat. This is usually a different mixture from the bulk of the proofing, and is called a "sticking-coat," its object being to secure adhesion between the fabric and rubber; it is generally incorporated with colouring pigments, white or black, so as not to allow the general mixture to show through the cloth, or alter its appearance. A little zinc oxide, or whiting, is used for white or light-coloured goods; Frankfort and other blacks are used for dark goods. The coats, as applied, are dried by passing over a steam-chest, when the fabric is again brought to the front of the machine for another coat, and so on. Some descriptions of goods have a finishing coat of better quality or mixture, in some cases containing no sulphur, nor any pigment whatever. The number of coats varies from three to seven, according to the class of goods and the weight of material which is to be put on.

Machines are now employed which work on the continuous principle; but as they require more space, so as to allow each coat to dry in time to receive another, it is not certain that there is much gain in using them.

Double textures are obtained by passing the proofed fabrics through a pair of rollers (the doubling-machine), whilst the surfaces are still sticky or adhesive; these are vulcanised, if required, by means of sulphur incorporated with the compounds, and steam heat. The doubling-rollers are of solid cast iron, with turned surfaces, 6 ft. long. One is fixed, while the other can be moved by a lever, so as to admit the fabrics to be doubled. As they revolve in opposite directions they draw the fabric through, and, when tightened up, press the two coated surfaces together.

The spreading and doubling can be done at one operation, the roll of fabric passing under a knife, in the front of which is placed, along its whole width, a roll of dough or cement; two beams of yarn, warped in the usual manner, passing through a reed, and on to the adhesive surface. The pressure regulated by a screw on the rollers firmly unites the whole into one fabric. Instead of the yarns a woven fabric or fleece may be employed. The rollers are hollow, so as to admit steam.

Drying Spread Fabrics.—After the goods leave the spreading-machines they are hung up for a few days in a warm room, so as to expel the little naphtha which is retained by the rubber, and which it gives up very slowly. This drying helps to remove the smell of the naphtha, and prevents blistering in curing. The quality of the solvent used, and the temperature of the drying-room, determine how long this "hanging up" must last before curing. As rubber licks up, as it were, the vapours and odours which float about in the drying-room, it would be infinitely better to have a series of drying-rooms, so as not to hang up the more recently spread goods with those which have more or less completely lost their smell of naphtha. Goods which are cured by the cold process are hung up in the same way; but as they have always a more disagreeable smell, they should have a separate hanging-room to dry in.

Curing and Vulcanising Fabrics.—(*a*) When spread cotton goods have become tolerably firm, or quite dry, they are wound upon hollow sheet-iron cylinders for curing in open steam, or in a steam-jacketed heater. As the condensed steam spoils these goods, they are carefully wrapped up as air- and water-tight as possible. Since wool and silk are destroyed by the heat necessary to cure rubber in this way, the cold process is the only eligible method of vulcanising. Very frequently, however, cotton goods are treated in the same manner.

In packing the goods for the steam-heater care must be taken that the fabrics are wound without creases, and are not stretched, as the fibres of the cloth, after curing, will retain their distorted appearance. Double textures are simply wound up; but "surface" goods are first carefully brushed over with very fine French chalk, no excess or loose chalk being allowed to remain. They are then wound up; but, as this necessitates the rubber surface coming into contact with the cotton surface, whereby it is liable to be marked, it is more usual to run two pieces together, with the rubber surfaces against each other. This not only prevents marking, but secures an even surface; blisters, from dampness in the cotton, are also prevented.

(*b*) Parkes' process of vulcanising with sulphur chloride is extensively used for surface curing, such as single textures for garments, and sundry small articles manufactured from masticated sheet rubber, as tobacco-pouches, tubing, rings, etc. The chloride is mixed with 30–40 times its bulk of carbon bisulphide for ordinary fabrics; but for solid rubber goods much more dilute solutions must be used, and a longer immersion allowed, than with stronger solutions, since the surfaces would be overcured, and crack. Sulphur chloride in vapour is preferable in many cases to the mixture in carbon bisulphide. The articles are then suspended in a lead-lined chamber, well varnished with shellac, and heated by steam-pipes; the chloride is gently evaporated, either by placing it in an open dish on the steam-pipes, or by using a small retort, the end of the tubulure of which passes into the chamber. The chloride is evaporated by a small gas-burner. Chlorine, bromine, hypochlorous acid, and several other vapours can be used in the same way. Although Parkes uses these vapours with solvents of rubber, they act equally well, and in many cases more certainly, without them.

(*c*) Several improvements for curing double textures have been recently introduced, the most important of which is the Silvertown process. This consists in passing the rubber surface of each piece to be united over a roller, revolving in a mixture of sulphur chloride and carbon bisulphide; the acid mixture does not come into contact with the fabrics, so that no injury can happen either to the colour or the fibres, and the most delicate tissues can be treated. Another process, by Anderson and Abbott, effects the curing by suspending the fabrics or completed garments in a chamber, which is afterwards charged with the vapours of sulphur chloride; it is questionable how far this method can be depended upon without injury to the fabrics. If the colours are discharged by the sulphur chloride, they are brought back by placing a dish of liquid ammonia in the drying-room.

Single textures are cured by passing the coated surface over a roller, revolving in the curing-mixture, as above. The fabrics are run on to a large drum, and the cured surface, which is still sticky, is kept from coming into contact with the cloth surface by making the drum pick up a roller whenever its arms pass the frame which supports them, so that between each two layers of material there is a space of about 2 in.; as soon as the bisulphide has nearly all evaporated, the fabrics are run on to a roller for hanging up.

(*d*) Under ordinary conditions rubber for vulcanising is usually mixed with sulphur and heated to a high temperature, when chemical combination takes place between the sulphur and the rubber, producing a much more valuable compound for ordinary purposes than unvulcanised rubber; the former remaining soft at very low temperatures and firm at high temperatures, whilst the latter becomes hard and quite plastic respectively at those temperatures.

In making cloth for waterproof garments another method is employed for vulcanising the rubber, viz., by wetting its surface with a mixture of somewhere about 5–10 parts chloride of sulphur dissolved in 100 parts bisulphide of carbon, and then heating the fabric gently to evaporate away the excess of these substances; the rubber-covered cloth cannot be heated to a high temperature like the rubber alone, because the heat would be liable to injure the cotton, silk, or wool of the fabric, or destroy or injure the colours.

The bisulphide of carbon softens and penetrates the fine layer of rubber, carrying with it the chloride of sulphur dissolved in it, and it is generally supposed that the chloride of sulphur breaks up, the sulphur combining with the rubber producing vulcanisation, and the chlorine combining with the hydrogen producing hydrochloric acid, which is liberated. This reaction is clearly not the correct one, and it is probable that the reverse is more in accordance with the facts, viz., that the chlorine of the sulphur chloride combines with the rubber producing vulcanisation, leaving the sulphur in the free state, or only partially in combination with the rubber, because in rubber vulcanised by the cold process I have found free sulphur to be present.

From a piece of rubber-covered cloth I separated the rubber, and submitted it to analysis by mixing it thoroughly in small pieces with pure sodium carbonate and igniting, then dissolving the whole in water and adding to it peroxide of hydrogen previously treated with excess barium chloride (to separate sulphuric acid or sulphates). The peroxide ensures the conversion of the lower oxides of sulphur into sulphuric acid, whilst the excess of barium chlorides precipitates the sulphuric acid in the solution, which is then weighed as barium sulphate.

Another portion of the made-up

solution was neutralised,* and the chlorine present titrated. The rubber previous to ignition, as above described, had been well boiled in water and dried to separate any hydrochloric acid which might be present, but only a faint trace of chlorine compound could be thus separated from the rubber.

The total sulphur present in the rubber amounted to 2·60, and the total chlorine to 6·31 per cent.

The yellow-coloured sulphur protochloride is best adapted for vulcanising, because it does not act too strongly upon the rubber, whilst the dark-coloured chloride of sulphur, containing as it does a large quantity of the higher chlorides of sulphur, is liable to render the rubber quite hard by vulcanising it too much. The theory generally adopted to explain this is that these higher chlorides break up easily, liberating their sulphur, which thus combines in greater quantity with the rubber; but my experiments and analyses prove that it is chiefly the chlorine and not the sulphur of the chloride of sulphur which produces the vulcanisation. (W. Thomson).

Solvents.—Benzine is an excellent solvent for caoutchouc and gutta-percha. Caoutchouc or rubber may also be dissolved in ether, carbon sulphide, naphtha, spirit of turpentine, and chloroform.

Solutions.—(*a*) A mixture of 6 parts absolute alcohol with 100 of carbon sulphide; the latter is the real solvent, the alcohol has an indirect action. The quantity of solvent required depends on the consistency of solution required; if moderate heat is used, and the mixture is shaken, the whole dissolves, but a better solution is obtained for adhesive properties by using a large quantity of solvent, not shaking, but drawing off the clear glazy liquid. (*b*) For a small quantity place 1 fl. dr. sulphuric acid and the same quantity of water into a phial bottle, and well shake together. Great heat is evolved. Allow to stand till cool; then add 2 fl. oz. spirits of turpentine and shake well. Great heat will again be evolved, and the colour changed to deep cinnamon. Allow to stand for 24 hours, after which a strong dark sediment will have settled at the bottom of the bottle. Pour off the clear liquor into another bottle, and add 1½ dr. common rubber cut up into fine shreds, and then place it uncorked over a very gentle heat, and allow to boil slowly for five hours. At the end of that time the rubber should be perfectly dissolved. It can be concentrated by longer boiling, or thinned by the addition of more turpentine.

Joining and Piecing Fabrics.

(*a*) Make a long bevel on the ends to be joined with a sharp rough-edged knife and water, scrape the bevels rough with the edge of the knife, and, when quite dry, give each a coat of rubber solution. When the first coat is dry, give it another, and when that is dry, put the two ends together.

(*b*) Cured or uncured fabrics are joined for garment-making and other articles by cementing together with thin solution. Several coatings are applied, each being allowed to get nearly dry before the next is rubbed on; the two adhesive surfaces are then well rolled down by manual labour, and the excess of cement which oozes out is rubbed off, when nearly dry, by a piece of masticated block rubber. Double textures are stripped, so as to cement the rubber surfaces, by applying first a little solvent, which renders the stripping-off easier. In spreading it is necessary to coat one of the fabrics with less pressure, so as not to drive the rubber into the meshes of the cloth. Such coatings are specially designated "stripping-coats." Without such arrangement double textures could not be made with watertight seams.

Adulteration and Rubber Substitute.—A rubber substitute, much used at present, is produced by acting on vegetable oils, such as rape, linseed, etc., with a mixture of chloride of sulphur and bisulphide of carbon; the oil becomes converted into a solid substance resembling rubber to some extent, but being much more brittle. This body is now used in large quantity for mixing with rubber for the purpose of cheapening its production. On analysis of some samples of this material I have invariably found that it contained a much greater proportion of chlorine than of sulphur, and this process therefore is a vulcanisation by chlorine rather than by sulphur.

Recently I analysed three samples of rubber substitute, the one termed "special" another "spongy" rubber substitute, the third being similar to the first in appearance. The first contained of sulphur 3·4 and of chlorine 7·6 per cent.; the second contained of sulphur 4·56 and of chlorine 8·22, and the third 2·67 of sulphur and 7·90 of chlorine per cent.

These rubber substitutes contain considerable quantities of oily matters soluble in ether, which I have also found to be chlorine and sulphur compounds of the oils. The first yielded 20 per cent., the second 14·3, and the third 11·5 per cent. of these thick oily matters soluble in ether. This oily substance from the first sample contained 2·6 per cent. of sulphur and 6·1 per cent. of chlorine, whilst that from the second contained 2·97 and 6·87 per cent. of sulphur and chlorine respectively.

Some rubber manufacturers regard this oily matter as injurious to the rubber, and reject any substitute which contains any considerable proportion of it. I have found, however, by experiment that this oily compound instead of acting injuriously on rubber, actually acts as a preservative of it; some rubber threads were smeared with this oily extract, some with ordinary (unvulcanised) rape oil, and some left untreated; these were put into an incubator at 150° F. for a few days, when it was found that the oil-treated rubber was quite soft and rotten, whilst the other two had remained sound; after a few days more the original rubber threads had become quite rotten, whilst the threads smeared with the oily part of the vulcanised oil remained quite sound.

The first and second samples of rubber substitute were examined for soluble chlorides or hydrochloric acid by boiling in water; the first gave 0·18 per cent. of chlorine soluble in water, and the second 0·05 per cent.

Effects of Copper on Rubber-coated Fabrics.—It has been known for some time that copper salts exert a most injurious influence on rubber. Copper salts are sometimes used in dyeing cloth, which are afterwards employed for waterproofing with rubber, and it seems quite astonishing what a small quantity of copper is required to harden and destroy the rubber, and the destructive effect of copper is further enhanced if the cloth contains oily matter in which the copper has dissolved.

As an example, a piece of cloth, alleged to have damaged the thin coating of rubber on it, was found to contain copper, and, with a view of demonstrating this point, I took one piece in its original condition. To the end of this I pasted a similar piece of cloth from which the oily and greasy matters had been removed by ether, and to the end of this again I pasted another piece of the same cloth, from which I had removed both oily and greasy matters and copper; these three pieces, joined end to end into one, were then coated in the usual way with rubber, and then hung in an incubator at 150° F. In the course of a few days the rubber on the original cloth had become soft, and it then hardened and became rotten and useless; the second piece, from which the greasy matters had been removed, then became quite hard and rotten, whilst the part from which both greasy matters and copper had been removed has remained in perfectly elastic and good condition.

Prof. Dewar observed accidentally that metallic copper when heated t the temperature of boiling water, i contact with the rubber exerted destructive effect upon it. With view of finding whether this was du to the copper *per se*, or to its power of conducting heat more rapidly to the rubber,* I laid a sheet of rubber on a plate of glass, and on it placed four clean discs, one of copper, one of platinum, one of zinc, and one of silver. After a few days in an incubator at 150° F. the rubber under the copper had become quite hard, that under the platinum had become slightly affected and hardened at different parts, whilst the rubber under the silver and under the zinc remained quite sound and elastic. This would infer that the pure metallic copper had exerted a great oxidising effect on the rubber, the platinum had exerted a slight effect, whilst the zinc and silver, respectively, had had no injurious influence on it. A still more curious result was this, that the rubber thus hardened by the copper contained no appreciable trace of copper; the copper, therefore, presumably sets up the oxidising action in the rubber without its permeating it. (W. Thomson).

Cuprammonium and its Allies. "Willesden" Products. The preparation of these salts and their application to the waterproofing of paper and textiles have been made the subject of much study by Dr. Alder Wright, to whom the following remarks are mainly due. The term "cuprammonium compound" is usually understood by chemists as indicating a member of the class of substances obtainable by the combination of ammonia with certain copper compounds, so as to give rise to a "metallo-ammonium" derivative containing copper. Salts of copper, e.g., copper sulphate, usually combine with four proportions of ammonia; thus cupro-tetrammonium sulphate is obtainable in crystals by simply pouring a concentrated solution of copper sulphate into a solution of ammonia in such proportions as to obtain a clear deep blue liquid, and then precipitating the crystallised salt by adding a considerable quantity of highly concentrated ammonia solution, or by shaking with alcohol; in a similar fashion numerous other cuprotetrammonium salts can be obtained. A closely related compound, but possessing somewhat different properties, is cupro-ammonium hydroxide, prepared by dissolving cupric hydrate in ammonia solution, or by agitating together metallic copper and ammonia solution in presence of air, when the copper oxidises and dissolves in the ammoniacal liquor, forming a deep blue liquid, sometimes termed "copperised ammonia."

Most of these compounds are very unstable, breaking up under the influence of heat and water alone, or conjointly; thus cupro-tetrammonium sulphate treated with a large bulk of cold water is partly decomposed, forming a basic insoluble copper sulphate, together with free ammonia and ammonium sulphate; cupro-ammonium hydroxide solution is decomposed by simple addition of alcohol to its ammoniacal solution, a blue substance essentially consisting of hydrated copper oxide being precipitated; the same result ensues on boiling, save that anhydrous black copper oxide is then formed, ammonia being driven off. In presence of a large excess of ammonia the instability is less marked in all cases; the strongly ammoniacal fluids formed by dissolving copper salts or copper hydroxide in a considerable excess of ammonia water are the "cuprammonium solutions" referred to.

It has long been known that these solutions possess the power of apparently dissolving cellulose and various allied substances; thus paper, cotton-wool, and similar materials, when digested with these fluids, disappear, and are apparently truly dissolved. It is held, however, by some chemists that these are not cases of true solution, but that the substances are simply gelatinised and disseminated through the fluid in a transparent form, as starch is in water. On the other hand, on neutralising the fluid by an acid, or, better still, on adding potassium cyanide solution until the blue tint is discharged, the cellulose reappears as a gelatinous precipitate; this result would suggest that the reappearance of the cellulose is brought about by the destruction of the solvent in which it was truly dissolved, viz., the cuprammonium compound, by conversion into ammonia and cupro-cyanide (or into ammonic and cupric salts, if an acid be used). On evaporation to dryness of a cuprammonium solution in which cellulose has been dissolved, a more or less gummy mass is formed, containing the cellulose intermixed with copper oxide, and with ammonia and copper salts if a cuprammonium salt were used, but containing copper oxide and a green copper derivative or compound of cellulose if cuprammonium hydroxide were employed. When the cellulose is in excess, e.g., when the solution is evaporated on the surface of paper or calico, just dipped in the solution, black copper oxide is often not formed at all; but a green varnish-like mass of cellulose conjoined with copper oxide, or of the copper salt of some feeble acid derived from and closely akin to cellulose, coats the surface of each filament of the fabric used, welding and cementing them together. This cement-like "cupro-cellulose," as it may be termed, being insoluble in water, communicates water-resisting properties to the material so treated; moreover, the presence of copper renders the dipped and dried substance less prone than before to the attacks of insects and mould, so that animal and vegetable life of a parasitic nature and fungoid growths are rarely, if ever, to be observed in the substances, even when kept under conditions where boring worms, ants, rot, and mould would be likely to attack them.

To produce the best results in this direction solution of cuprammonium hydroxide is, for many reasons, preferable to solutions containing cuprammonium salts; not only is the action on cellulose more energetic for a given amount of copper and ammonia in solution, but various other advantages are gained. For example, if ammoniacal solution of cuprammonium sulphate be
used, the dried treated fabr
tain ammonium sulphate, a ics will con-
times copper sulphate, soluble nd some-
rendering the material porous water,
posed to the action of water in su f ex-
ent quantity to dissolve out the solu suffici-
matters, and causing more or ble
tendency to unsightly efflorescenc less
under other conditions. Further, dur-
ing the drying of materials treated
with cuprammonium hydroxide solu-
tion all the ammonia present is vola-
tilised, and may be recovered by ap-
propriate means; whereas, with cu in
prammonium sulphate solution a ards
siderable fraction of the ammoni with
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A peculiar property of cupram the
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is that whereas iron is, as is well kn copper
attacked and dissolved by solutio
ordinary copper salts (e.g., the cloth,
phate "blue vitriol"), an equiv coat-
quantity of copper being precipi con-
during the operation, no such act mon-
observable with cuprammonium ece in
drate solutions; so that cast and
wrought-iron tanks and baths f cloth
reception of the liquor may be atter
with impunity, as may steel to th
and machinery of all kinds whe othe
ployed in contact with the liq whic
with fabrics moistened therewith rea
the other hand, copper and brass iece
be studiously avoided in the co th
tion of such appliances, otherwi ubb
rosion and injury are speedily b or
about. This peculiarity, as regards
non-action of iron and steel, is
more remarkable in that it is not
served with zinc; this latter me ob-
precipitating copper (and being ita al
dissolved) with about equal facility
whether the copper be in the form of
an ordinary copper salt or in that of
a cuprammonium solution.

For certain purposes a bath contain-
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lose to give good results, but when used in conjunction with cuprammonium hydroxide, pectising is brought about by the copper solution, whilst certain advantages are gained by the simultaneous presence of zinco-cellulose and cupro-cellulose in the finished goods. The manufacture of cuprammonium and zinc-ammonium solutions is effected by the simultaneous action of air and ammonia water on metallic copper (or brass, if a mixture of cupro- and zinco-ammonium hydroxides is required), due attention being paid to the recovery of the large amount of ammonia necessarily carried away by the "spent" air during the operation. The manufacture of fabrics, notably paper and canvas, treated with cuprammonium solutions so as to waterproof them and render them rot-proof, and practically free from the attacks of insects and mould, is practised on the large scale at Willesden by the Patent Waterproof Paper and Canvas Co.

The process by which these fabrics are manufactured may be described as essentially consisting of the preparation of a concentrated solution of cuprammonium hydroxide, and the passing of the goods to be treated through a bath of this material at just such a rate as will permit of the pectising and gelatinising of the exterior of the fibres composing the paper or canvas, etc., without wholly disintegrating the mass; so that the material on emerging from the bath retains coherence sufficient to enable it to be passed over and under the usual drums, etc., of a paper mill, and so to be dried in the ordinary way. This drying converts the film of pectised cellulose coating each filament and fibre into an insoluble solid varnish which cements the whole together. In order to build up thick cards two or more reels of paper are employed, passed simultaneously through the bath, and then pressed together and dried as a whole, two thicknesses thus treated forming 2-ply card. The best kinds of thick cards are made by passing two rolls of 2-ply simultaneously through the bath a second time, and pressing them together and drying, thus giving rise to 4-ply card, the thickness mostly adopted for roofing. By repeating this process with two batches of 4-ply, 8-ply is obtained; and similarly to any required degree of thickness necessary for special purposes.

A noteworthy point in connection with these processes is that, when certain precautions are taken, the copper present in the ammoniacal fluid imbibed by the material passed through the bath is wholly converted during drying into a compound with the pectised cellulose of an agreeable green tint, and is not deposited as black copper oxide, as it would be on evaporation of the solution without cellulose in a porcelain dish, etc. It is largely the presence of copper in this form that renders Willesden fabrics so free from growths of mould, mildew, rot, and fungoid vegetation generally, and from the attacks of insects. The compound is so stable as to be wholly unaffected by water, when once dry. Of course, mineral acids dissolve out copper to some extent, but this is not the case with ordinary water, apparently not even with London rain.

Instead of cuprammonium hydroxide alone, in certain cases a mixture of cuprammonium and zincammonium hydroxides may be used. The pectised cellulose then contains both zinc and copper, indicating apparently that a zinc cellulose compound has also been formed. Zincammonium hydroxide alone, however, does not pectise paper sufficiently to give good results. In order to pectise paper, etc., thoroughly, when the materials are passed through the baths at a convenient manufacturing speed, it is essential to use a liquid containing 100–150 lb. of ammonia per 100 gal.* (about as much ammonia as is present in solution of ammonia, sp. gr. ·940 to ·960). Such a fluid, when nearly saturated with copper present as pure cuprammonium hydroxide, will contain 20–25 lb. copper (reckoned as metal) per 100 gal. Considerably larger amounts of copper, however, may be taken into solution in the form of cuprammonium salts, or when certain forms of organic matter are also present in the liquor. According to the textbooks ammoniacal solutions of cuprammonium salts dissolve cellulose, but such fluids are found to be unsuitable for the manufacture of Willesden goods, for a variety of reasons. In the first place, for a given quantity of copper in solution an ammoniacal solution of cuprammonium hydroxide appears to possess a considerably higher pectising power than a similar solution of a cuprammonium salt; next, when a cuprammonium salt, e.g., the sulphate, is used, there is not only a tendency to form a little copper sulphate, which can be washed out of the finished fabric by water (thus rendering the material unsuitable for many purposes, e.g., cattle drinking-troughs, portable sheep-pens, etc.), but, further, much ammonium sulphate is formed in the body of the fabric, thus giving rise to a double disadvantage: first, because the ammonia thus fixed is wholly lost, whereas the ammonia in cuprammonium hydroxide is wholly volatilised during the drying, and can be recovered and used over again; secondly, because when the fabric is wetted, the ammonium sulphate is washed out, thus partially opening the texture, and rendering the mass more porous and less impervious to moisture; beside which, the ammonium sulphate sometimes effloresces as an unsightly saline film. For these and other reasons cuprammonium hydroxide, and not a cuprammonium salt, is employed in the manufacture of the so-called "Willesden" goods.

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* 1 lb. per 100 gal. = 1 grm. per litre.

These goods are divisible into two classes, viz. (*a*) round or made-up, such as rope, cordage, netting, etc., and (*b*) rolled or flat.

Goods of the first class (*a*) are prepared by simply dipping the made-up materials to be treated into a bath of cuprammonium solution, using certain precautions as to the mode of immersion and its duration, and the strength of the solution. On subsequently drying the dipped fabrics, they are obtained coated and impregnated with cupro-cellulose, which thus not merely forms a kind of varnish-like surface dressing, but further adds strength to the fibres by more or less intimately cementing them together. The freedom from liability to mildew and rot of these products is remarkable, whilst they possess many advantages as compared with similar goods protected by tarring, or dipping in the bark vat, or treatment with other preservative compositions.

Goods of the second class (*b*) constitute a much more important group. These fabrics are essentially of three kinds, viz., canvas, scrim, and paper. The former two of these classes possess many features in common with the round or made-up goods just described, being prepared in much the same way, saving that the fabric to be treated is usually unwound from one roller and rewound upon another, after passing successively through the bath and a series of drying rolls somewhat analogous to those of a paper mill. Like Willesden cordage and netting, they exhibit remarkable freedom from moulding and mildewing influences.

Willesden paper manufacture may be subdivided into two departments, viz., (1) unwelded, (2) welded (rolled) goods, the first class being a single web or ply of paper of indefinite length passed through the bath, and rolled and dried in much the same way as canvas and scrim; the second class consisting of more than one ply or layer of primary material, incorporated into one solid insoluble sheet or homogeneous panel of indefinite continuous length.

1. Unwelded or "1-ply" paper exhibits much the same general resistance to mildewing and moulding influences as Willesden canvas and cordage. According to the nature of the paper originally treated, different kinds of 1-ply result. Certain coarse varieties

furnish a waterproof material excellently adapted for lining packages and wrapping parcels liable to be exposed to damp during transit, and of special value as a first coat of paper to be applied to damp walls. Finer qualities furnish envelopes and stationery possessing the valuable property of not being affected by water. Letters written with such stationery would be as legible as ever (provided the ink were not washed away or bleached), even if the mail-bags containing them were sunk in the ocean or washed overboard, and not recovered until after long periods of immersion. In connection with this may be noticed a mode of fastening envelopes, affording security against opening and tampering with contents, impossible with ordinary gummed envelopes, or with those secured by sealing-wax, either of which, as is well known, can be readily opened by a skilled person, and reclosed without noticeable alteration (an impression of the seal being of course taken in the case of sealed letters, and subsequently used to re-seal them). This method consists in using as fastening material a concentrated cuprammonium solution; the edges of the envelope are moistened therewith, whereby the paper is gelatinised; the envelope is then closed and ironed with a warm flat-iron, when the gelatinised cellulose is converted into an insoluble cupro-cellulose, and the cover is fastened down so securely that the only possible mode of opening is to tear the paper. No amount of steaming or treatment with water will undo the cement, as it would with a gummed envelope. Another application of this same principle consists in the use of a wafer of "Willesdenised" paper, moistened with cuprammonium solution before use. Obviously, the same principle may be applied in the direction of cementing together the edges of sheets of paper so as to form larger sheets, fixing firmly together paper, pasteboard, wood, and analogous surfaces, book-binding, and in numerous other ways; troughs and dishes, water-tight boxes and packing-case linings are readily prepared thus.

2. Welded Willesden goods have undoubtedly the merit of being the most remarkable and interesting of all, on account of their important applications; they are all prepared in substantially the same way, viz., by simultaneously dipping more than 1 ply, and pressing into one compact homogeneous sheet the various layers, whilst still gelatinised or pectised by the action of the cuprammonium solution. According to the nature and thickness of the finished material various subdivisions of this class may be tabulated, e.g.:—8-ply, panel board; 4-ply, for roofing, building, panelling, decorating; 2-ply, for underlining, interior decoration, floors, damp walls, packing, leaky roofs; 1-ply, described above as unwelded Willesden goods.

Besides these, various kinds of combination fabrics may be noticed, such as those obtainable by simultaneously treating paper and calico, and welding the two together so as to form an article resembling ordinary mounted drawing paper, but differing therefrom in the important character that long-continued immersion and even long boiling in water causes not the least disintegration or separation of the two diverse fabrics thus combined; so that military and submarine engineers' and surveyors' plans, and the like, drawn on such paper would be uninjured by being exposed to wet and rain, if the colours or ink were of suitable kinds, so as to resist the action of the water.

Willesden 8-ply is adapted for panel work and use where great strength is required, and is valuable owing to its being made (to special order) 54 or even 60 in. wide, and in continuous lengths; from the nature of this material there is no fear of its cracking or splitting like ordinary panel board. For boat-building and naval construction generally it is well adapted.

Willesden 4-ply, next to slates and tiles, stands pre-eminent as a durable roofing material, unassailable by weather of all kinds; whilst its strength, combined with lightness and flexibility, render it a most valuable and unique article for practical use and service; more especially are these advantages manifest in connection with up-country and foreign employments.

It would come far cheaper than galvanised iron, in any locality where the cost of transit is heavy, more especially in new districts where the means of communication with the seaboard are but imperfectly opened up. Again, being put up in compact rolls (ordinarily of 2 cwt. each), no space is wasted in packing. Another special advantage is, that being comparatively non-conducting, the heat of a tropical sun is less felt under a roof of this kind than under a metallic one; whilst, on the other hand, the condensation of moisture from warm air inside a hut thus roofed or walled is all but imperceptible, even on a cold night; whereas an iron building, under similar conditions, frequently gives an inconvenient drip of condensed water from the roof, and small streams running down the walls.

For building purposes generally, and interior use, 4-ply offers many advantages. Where the buildings are temporary and intended for subsequent removal elsewhere (e.g., workmen's huts when engaged in railroad construction), the lightness of this material renders it eminently adapted for construction in removable sections; and for more permanent structures it is equally advantageous for numerous reasons. It does not harbour moths or other vermin; in the hottest weather, under a broiling tropical sun, it remains unchanged, and emits no unpleasant odour; it requires no painting, and exempts from the necessity of using pot and brush year after year to prevent corrosion, or to make a neat surface, or render water-tight, being weatherproof in itself. If required for internal decoration, however, it will take paint readily, and, indeed, forms an admirable foundation for the painter and decorator to work upon, in this respect having marked advantages over felt with which material it has nothing in common, although the two can, if desired, be used in conjunction. In case of fire, although not absolutely indestructible, yet "Willesden" will not readily feed the flames, the copperising and compacting process by which it is made rendering it far less inflammable than such substances as painted or tarred felt, or wooden shingling; its lightness, moreover, renders much less massive timbering requisite for the support of roofs, thus again diminishing the risk of damage by conflagration, there being actually less combustible matter about a building erected with this material than is necessary when the weight of a slated or tiled roof has to be supported. A special method of fixing walls and roofs of Willesden paper is recommended (see 'Spons' Mechanics' Own Book,' pp. 618–20). Many such roofs are now standing in perfectly good condition, after upwards of eight years' exposure to weather of all sorts; similarly, pipes conveying both water and steam have been in use upwards of three years below ground at the Willesden works without any visible deterioration.

Willesden 2-ply is susceptible of being used for many purposes for which 4-ply is applicable, more especially when a less degree of body and substance will suffice. One special purpose to which it is excellently well adapted is for laying upon or under floor-boards and joists, to avoid damp and draughts. Used as a floor-cloth for stairs and offices, it wears well and is most effective, the cost being only a fraction of that of linoleum, kamptulicon, and similar articles.

Boats made of the paper answer very well in fresh water, but have not been tested in salt water. One advantage in making boats of the paper is that they are lighter than those made of wood, and, in the next place, are very easily repaired. Photographic dishes can easily be made by taking a sheet and pinching up the corner, bulging being prevented by running a thread through the corners. These dishes can be used for chemicals, though it is not advisable to put in a second chemical if the first has remained in the dish for some time. The action of acids upon the card depends upon the concentration as well as the nature of the acid and the temperature. If the card were boiled in a beaker, with weak sulphuric or hydrochloric acid, beyond doubt copper in solution would be found, and, no doubt, there would be less copper in the card than there was before; but, in the cold, very little copper is dissolved out. It is unlikely that the solution of copper in this way would affect the stability of the material for use in galvanic cells. Whether this material can be used for vats for bleaching purposes is a matter which experience alone can decide, though there is nothing in the character of the material which would unfit it for the purpose. At the same time it is doubtful whether oil of vitriol could be kept in a vessel made of Willesden paper. With regard to ropes being only superficially tinged with the coppery material, that partly arises from the circumstance that the rope is purposely not immersed sufficiently long to enable the fluid to penetrate deeply. As the action of the solution is to dissolve and disintegrate fibres, if thin ropes were saturated all through, they would lose a certain amount of strength. It is not necessary that a rope shall be saturated throughout. As to the paper treated at Willesden, complete penetration of the fluid into each ply of paper is a necessity, in order to obtain a proper product. The principal difficulty in carrying out the process consists in exactly regulating the strength of the solution as regards the amount of copper and ammonia, the nature of the paper and the length of time during which it has to pass through the vat, in order that the solution shall pass into the interior of the paper to the proper extent and no more; for if the action of solution is overdone, the material becomes too soft and tender to be dealt with by the machine. Both the canvas and paper are susceptible of use as a medium for painting, though canvas has not been long in use; but there is every reason to believe that works of art on canvas treated by this process will be less subject to deterioration through injury to the foundation. The paper would have no effect upon any mineral colour employed for decorative purposes. The action of copper upon certain organic dyes is well known, but these substances are rarely used for painting. The paper can be moulded into any shape. As to the analogy between this paper and paper parchmentised with sulphuric acid, the two processes are dissimilar, though chemically the change produced on the paper fibre is of much the same character. There is a certain amount of analogy between the processes; if, for example, a sheet of writing paper is impregnated with cuprammonium to a fair extent, it has much the same texture when finished as parchmentised paper, and microscopically there is the same kind of structure. The quantity of copper left in the paper after treatment will vary very much according to the length of time the paper is allowed to remain in the solution, and the quantity taken up, but in round figures an analysis of 4-ply paper shows that it contains about 4 per cent. of metal. Among other uses to which the paper may be put are covering bricks in the brickfield, and making shelters for vineries. Upon the question of whether Willesden paper is a non-conductor for electricity or not, probably if the material were rolled up into a pipe and used for telegraph cables it would serve very efficiently, though scarcely with any advantage over guttapercha. It certainly does not conduct electricity readily; but as it contains copper, if there happened to be a leaky wire, reduction of metallic copper might be caused, whereby metallic communication would be set up from the wire to the earth, and, therefore, it is doubtful whether the substance could serve for the purpose of insulation. For chemical laboratories, and household matters, there are a considerable number of applications where the material will come in most handily.

MISCELLANEOUS PREPARATIONS.—A large number of compounds have been proposed at various times for rendering articles of everyday use more or less impervious to wet. These will now be collected together and arranged under four heads, according as they are designed more particularly for felt hats, leather, paper or textile goods.

Felt Hats.—(1) The stuff of coarse hat bodies is imbued with drying oil, prepared by boiling 50 parts linseed oil with 1 part each of white lead, litharge, and umber. The felt to be dried in a stove, and then polished by pumice; five or six coats of oil are required; the surface is at last varnished. When the hat is intended to be stiff, the fabric is to be impregnated, first of all with paste, then stove-dried, cut into the desired shape, and pumiced repeatedly; lastly placed in a hot iron mould, and exposed to strong pressure.

(2) Remove lining of hat, and paint the inside with Canada balsam, made hot. Hats made waterproof and not ventilated will bring on premature baldness; so punch a few small holes in the side.

(3) For waterproofing a soft hat, sponge the inside of the hat with a warm solution of soap, 2 oz. to the pint, and dry. If the hat is a light-coloured one, it could be dipped first in the soap, and then in the alum; this will more effectually waterproof the hat.

Leather.—(1) Add to a boiling solution of common yellow soap, in water, solution of alum or alum-cake (alumina sulphate) as long as a separation of white alumina soap takes place; allow the precipitate to subside, wash it with hot water, heat moderately for some time, to expel adhering water, and dissolve the semi-transparent mass in warm oil of turpentine. The solution may be applied by brush or by dipping and rolling. Oil and colours may be added to the bath, and the substance dried in the air, or more rapidly in a drying room at 90°–100° F. (32°–38° C.), with care to prevent fire.

(2) 100 oz. best white or yellow wax, 6 oz. Burgundy pitch, 8 oz. ground-nut oil, 5 oz. iron sulphate, 2 oz. essence of thyme.

(3) A method of waterproofing leather and raw hides, used in southern Austria, is as follows: Impregnate the substance with a gelatine solution, mixed with some mineral salt to coagulate the gelatine in the pores. The following mixtures can be used: (*a*) 1200 water, 15 gelatine, 5 potash bichromate; or (*b*) 1500 water, 50 gelatine, 30 potash bichromate; the temperature of the solution may vary from 50° F. (10° C.), to boiling-point. When the bichromate percentage is small, the liquor is used cold, and the leather or hide is immersed for 24 hours; as the proportion approaches the point of saturation, the temperature must approximate more nearly to boiling, and the time of immersion be reduced until it becomes momentary. The bichromate solution may be replaced by the following: 1000 water, 10 gelatine, 100 lead acetate, 100 alum; in every case, after impregnation on one or both sides, the leather or hide should be dried, and dressed on both sides with paraffin.

(4) For rendering hose of fire-engines completely water-tight so as to withstand the greatest pressure, the hose, after being cleaned and dried, is impregnated with a mixture of 100 parts of glycerine and three of carbolic acid, which may be done either by drawing the hose through the liquid, or, better still, by brushing it well in. Thus treated, the hose preserves a certain degree of dampness, without, however, being liable to rotting in the least degree, and so suffering deterioration in quality and durability. The brass fittings of the hose are attacked only imperceptibly by the acid contained in the composition; but even this may be easily prevented by giving them before impregnation a coating of weak shellac varnish, or by greasing them

well with tallow. The hose must be cleaned every time they have been used, dried, and impregnated anew with the liquid. The previous drying of the hose is, however, not necessarily essential, more especially in winter, when drying is slightly difficult; it suffices to let the water run well out of the hose.

(1) *Boots and Shoes.*—Apply to the soles as much copal varnish as they will absorb; and castor oil to the uppers. The castor oil does not prevent subsequent blacking.

(2) 1 oz. beeswax, ½ oz. suet, 2 oz. olive oil, ½ oz. lampblack; melt the wax and suet in the oil, add the lampblack, and stir till cool; warm the shoes and rub in the compound.

(3) Warm the boots by the fire and then rub in paraffin wax; it is, however, apt to soil the stockings by being melted out by the heat of the feet. A saturated solution of paraffin wax in cold naphtha, applied cold, is perhaps better.

(4) Mix together in a pipkin, on the fire, 4 parts tallow to 1 of resin, and having thoroughly warmed the boots, apply it, melted, with a painter's brush till they will not soak in any more. If the boots are well polished before applying the mixture, they will polish afterwards.

(5) Take about 1 gill of Macintosh's indiarubber waterproofing solution, dissolve it in 2 gills raw linseed oil, adding the oil to the solution gradually. With this liquor paint the boots, giving as many coats, at intervals of six or eight hours, to the leather as it will take in, which may be as many as ten or twelve. The prepared leather takes a brilliant polish.

(6) 1 part ozokerit in 2 parts castor oil, and 1 part lampblack added, makes an excellent application, as the boots will take a thin polish after.

(7) Salad oil 1 pint, mutton suet 4 oz., white wax and spermaceti of each 1 oz., melted together, and applied to the boots warmed before the fire.

(8) Much used by fishermen: Melt 3 oz. spermaceti in a ladle, and add ¾ oz. rubber, cut into thin shavings. When dissolved, add ½ lb. tallow, 2 oz. pure lard, and 4 oz. amber varnish. Mix well, and while still warm apply with a brush, giving two or three coats. It leaves a good polish, and is preservative as well as being waterproof.

Paper.—(1) It is a well-known fact that cellulose is soluble in cuprous ammonia solution; paper, linen, and other vegetable tissues laid therein undergo a sort of surface-amalgamation of the fibres, which alters their absorbent powers. A sheet of paper so treated, and dried afterwards, becomes impermeable to water, and this property is not effaced by subsequent boiling. Sheets of paper soaked in the solution and laid one upon the other and rolled become amalgamated into a kind of cardboard, possessing great elasticity and cohesive power. The cuprous solution may be prepared by agitating copper filings in a closed vessel containing liquid ammonia of ·88 sp. gr. (*See* CUPRAMMONIUM PROCESSES AND WILLESDEN PAPER).

(2) Dissolve 8 oz. alum and 3¾ oz. Castile soap in 4 pints water, and 2 oz. gum arabic and 4 oz. glue, separately, in 4 pints water; mix the solutions, heat slightly, dip in the single sheets, and hang up until dry.

(3) Waterproofing pasteboard may be effected with a mixture of 4 parts slaked lime in 3 of skimmed milk, with a little alum added. As soon as mixed, the pasteboard is brushed over with two successive coatings of the preparation, and thus becomes impervious to water.

(4) Take pale shellac, 5 oz.; borax, 1 oz.; water, 1 pint. Digest at nearly the boiling-point till dissolved, then strain. This forms also an excellent vehicle for water-colours, inks, etc. If required quite transparent, the lac should be bleached as follows: Dissolve shellac in a lye of pearl-ash, by boiling; filter and pass an excess of chlorine gas through the solution, which will precipitate the white lac. Wash and dry the precipitate, and cast it if desired into sticks.

(5) *Packing Paper.*—Dissolve 1¾ lb. white soap in 1 qt. water. In another quart of water dissolve 1½ oz. gum arabic and 5 oz. glue. Mix the two solutions, warm them, soak the paper in the liquid, and pass it between rollers, or simply hang up to dry.

(6) *Waterproof Paper for Boats.*—Sheets of stout manila passed through a hot bath of aqueous solution of zinc chloride (at 75° B.), pressed strongly together and then soaked in dilute aqueous soda solution containing a small amount of glycerin, cohere to form a strong, stiff, waterproof board admirably adapted to the construction of small boats. Single sheets of paper passed quickly through the zinc chloride bath, pressed, and washed, and dried, are waterproof, and may be otherwise joined to form waterproof boards by any suitable cement, such as the following: Good pitch and gutta percha (about equal parts) are fused together, and to 9 parts of this are added 3 parts of boiled oil, and ½ part of litharge; continue the heat with stirring until thorough union of the ingredients is effected. This is applied hot or cooled somewhat, and thinned with a small quantity of benzole or turpentine oil.

(7) *Grease-proof Paper.* — Parchment-paper is plunged into a warm solution of concentrated gelatine, to which has been added 2½–3 per cent. glycerine, and allowed to dry. The resulting paper is impervious to grease. If desired to make a paper waterproof, the same parchment-paper is dipped in carbon bisulphide containing 1 per cent. linseed oil and 4 per cent. indiarubber.

(8) *Parchment Paper* is obtained by thoroughly washing woollen or cotton fabrics, so as to remove gum, starch, and other foreign bodies, then immersing them in a bath containing a small quantity of paper pulp. The latter is made to penetrate the fabric by being passed between rollers. Thus prepared, it is afterwards dipped into sulphuric acid of suitable concentration, and then repeatedly washed in a bath of aqueous ammonia until every trace of acid has been removed. Finally, it is pressed between rollers to remove the excess of liquid, dried between two other rollers which are covered with felt, and lastly calendered. The product is suitable for diaphragms in dialytic operations.

(9) Treat the tissue to be waterproofed with chloride, sulphate, or other soluble salt or salts of zinc or cadmium, in conjunction with ammonia, applied in the form of a solution composed of about 3 parts crystallised zinc sulphate, or 3 parts of a solution of zinc chloride at 76° Tw. (47° B.), and about 2 parts of solution of ammonia of sp. gr. 0·875. The paper which it is proposed to treat is passed through a cistern lined with lead, and specially constructed for this purpose, with an arrangement of rollers, so as to allow the material to pass through at a speed varying from 30 to 36 yd. per minute, according to the thickness. In its passage through the liquor, the material becomes perfectly saturated. From the bath it passes through a pair of squeezing rollers, which remove the superfluous liquor, and harden it by compression. From the rollers it is next passed to a suspending apparatus, then hung along the room in folds in a temperature of 110° F. (43° C.), until it is sufficiently dry to be taken down. The rollers in the cistern, the squeezing rollers, and the suspending apparatus are so speeded that the material is taken from one to the other without any inconvenience or stoppage.

(10) Treat with glue, gelatine, or other similar substances, in conjunction with bichromate or chromate of potash, soda, or alumina, applied in the form of a solution of about 1 part glue or gelatine in about 8 of water at 160° F. (71° C.), and a solution of 1 part potash bichromate in 15 of water. The mode of treatment in this case differs from (9) only in two points. (*a*) During the time the material is traversing the bath, as already described, the solution is maintained at 160° F. (71° C.) by means of siphon pipes charged with steam;

(*b*) instead of suspending to dry, the material is immediately passed over three steam cylinders 7 ft. in diameter, carrying a pressure of 15–20 lb. to the sq. in. The cylinders are provided with gauges to indicate the pressure they are required to carry, and also with safety-valves to prevent this pressure from being exceeded. The bath must always be kept in a state of darkness.

(11) The paper is treated with acetate, sulphate or chloride of alumina, applied in the form of a solution of 1 part of any of these compounds in 6 of water at 160¾° F. (71° C.). The same conditions are required to produce a waterproof material with these compounds as those described in (9) and (10), with this difference, that it is not absolutely necessary to preserve darkness during the process.

Varnishes for Waterproof Paper. (12) Pulverise 1 lb. shellac and put it into a bottle with a sufficient quantity of alcohol to cover the resin; cork the bottle tightly, and keep it in a warm place until the resin is dissolved. To 1 qt. of the liquid add 1 oz. ivory black and ½ oz. camphor dissolved in alcohol. Apply with a varnish brush. If too thick to work well, thin with alcohol.

(13) Johnson's green vitriol is dissolved in water, a solution of soap is added to this, and the precipitate of iron soap which is formed is collected. When this precipitate has become dry, and is then dissolved in carbon bisulphide or in benzole, a fluid is obtained which leaves behind a waterproof layer upon paper or tissue. If the paper or tissue is to remain white, a solution of alum is used instead of that of green vitriol, and a white aluminium soap is then obtained, which is used in the same manner.

(14) Take 4 oz. clean guttapercha, dissolve in 1 lb. rectified resin oil; add 2 lb. linseed-oil varnish, boiling hot.

(15) 1 part dammar resin, 4–6 parts acetone are digested in a closed flask for two weeks, and the clear solution is poured off. To this 4 parts collodion are added, and the whole is allowed to clear by standing.

(16) 30 parts white shellac are digested with 500 of ether, and to the solution 15 of lead carbonate are added; it is then shaken for some time and repeatedly filtered.

(17) 5 parts glue are dissolved in 100 of warm water, and this solution is spread on paper. After drying, the paper is soaked for an hour in a 10 per cent. solution of alumina acetate and again dried, in order to give it a final glaze.

(18) 120 parts linseed oil are heated and poured into a mixture of 33 of quicklime and 22 of water, to which 55 of melted rubber have been added, stirring all the time. The varnish is strained and used hot

(19) 1 part guttapercha is carefully digested in 40 of benzene on the water bath, and the paper is covered with it. This varnish can be drawn or written on, and it does not render the paper transparent or spotted.

Textiles. — Without considering the methods by which cloth is waterproofed with rubber, there are several processes in practical use by which cloth is rendered non-absorbent of water—and for all practical purposes waterproof—without materially affecting its colour or appearance, greatly increasing its weight, or rendering it entirely airproof. These depend mainly upon the reaction between two or more substances, in consequence of which a substance insoluble in water is deposited in the fibres of the cloth.

(1) Lowry's process: 2 oz. soap, 4 oz. glue, 1 gal. water. Soften the glue in cold water, and dissolve it together with the soap in the water by aid of heat and agitation. The cloth is filled with this solution by boiling it in the liquid for several hours, the time required depending upon the kind of fibre and thickness of the cloth. When properly saturated, the excess of liquid is wrung out, the cloth is exposed to the air until nearly dry, then digest for five to twelve hours in the following solution: 13 oz. alum, 15 oz.

salt, 1 gal. water. It is finally wrung out, rinsed in clean water, and dried at a temperature of about 80° F. (27° C.).

(2) Paut's process requires a small quantity of oil, but in other respects resembles the last. It is given as follows: 1 lb. sodium carbonate, ½ lb. caustic lime, 2½ pints water. Boil together, let it stand to settle, then draw off the clear lye, and add to it 1 lb. tallow, ½ lb. resin, previously melted together. Boil and stir occasionally for half an hour, then introduce 3 oz. glue (previously softened), 3 oz. linseed oil, and continue the boiling and stirring for another half hour. In waterproofing, ½ oz. of this soap is mixed with 1 gal. hot water, and in this the goods are soaked for about twenty-four hours, according to thickness and character. The pieces are allowed to drain until partly dried, then soaked for six hours or more in a solution prepared as follows: 1 lb. aluminium sulphate, ½ lb. lead acetate, 8 gal. water. Shake together, allow to settle, and draw off the clear liquid. Wring out after rinsing, and dry at a temperature of 80° F. (27° C.).

(3) Bienvaux uses, instead of glue and oil as above, the gelatinous portion of sea-wrack grass, with a small quantity of a drying oil and common resin-soda soap.

(4) In Reimann's process, the cloth is passed slowly by machinery through a tank divided into three compartments, the first containing a warm solution of alum, the second a warm solution of lead acetate, and the third pure water, which is constantly renewed. The cloth on passing from the latter is brushed and beaten to remove the salt adhering to the surface, and finally hot-pressed and brushed. In this case, lead sulphate is deposited in the fibres.

(5) In Townsend's process, two solutions are used as follows: 20 lb. dextrine, 10 lb. white soap, 16 gal. water. The solution is boiled for some minutes, and, if colour is required, 1 pint logwood liquor is added. The second solution consists of a saturated solution of alum in water, or 6 lb. zinc sulphate, 9 gal. water.

(6) Bullard's process is somewhat similar to Reimann's. In this, strong aqueous solutions of aluminium sulphate and lead acetate are used alternately.

(7) *Berlin Waterproof Cloth* is said to be prepared by saturating the cloth in a solution of aluminium and copper acetate, then dipping it successively in water-glass and resin-soap.

(8) A bath heated to 194° F. (90° C.) is made of 13¼ lb. liquid Bordeaux turpentine, 3¼ lb. tallow, 1 lb. wax, and ¼ lb. storax; the articles are immersed for a few minutes, then passed between heated rollers to remove excess.

(9) Some years ago the Belgian War Department conducted a series of experiments at Valvorde on the waterproofing of soldiers' uniforms by means of liquid alumina. With respect to the hygienic side of the question, the medical authorities satisfied themselves that the articles of dress thus treated permit the perspiration to pass off freely, and chemical analysis proved that the preparation used in no way injured the materials, or destroyed their colour. More than 10,000 yd. of materials, re-dressed two or three times over, notwithstanding the rinsing and washing to which they had been subjected after having been soiled, and after constant wear, remained perfectly waterproof. The only drawback to the process appeared to be that it is not very economical, and to ensure the desired result must be conducted on a large scale, which requires a considerable amount of plant. The following is the process employed:—Alumina acetate is obtained by making solutions of equal parts of alum and lead acetate in separate vessels, and then mixing them together. Lead sulphate will be thrown down, leaving alumina acetate in solution, which must be decanted. The materials to be waterproofed are soaked in this solution, and then with-

drawn without being wrung, and dried in the air.

(10) Bellefroid produces an impermeable coating, which consists firstly of a solution of stearine pitch, one of the by-products of candle-making, which pitch, in order to be used in the fabrication of the compound, is previously completely oxidised by exposure to the air. In order to complete this oxidisation, the pitch is spread out in very thin layers, and exposed to the outer atmosphere for a period of at least two years. This exposure is absolutely necessary, judging from experiments repeatedly made. The solution is afterwards effected in the following manner. A mixture consisting of 75 lb. stearine pitch, 150 lb. water, and 5 lb. caustic soda at about 35° to 36°, is put into a boiler or vessel of any suitable shape, having a second or double bottom so as to allow of the removal of impurities which will settle at the bottom of the vessel. The mixture is boiled for twelve hours over a strong fire, after which 52 pints water are added, and the boiling is continued for another twelve hours. The solution thus obtained is then poured out in an open vessel, and left exposed to the open air for eight days, for the purpose of being clarified, and enabling the impurities to settle at the bottom.

(11) Piron has invented a process for tanning textile fabrics, which renders them waterproof, and at the same time, it is said, proof against decay, while their suppleness is not diminished, and their weight not appreciably increased. Arguing from the high state of preservation in which the bands which surround the heads of Egyptian mummies are found to this day, and which are impregnated with a kind of resin, Piron had recourse to the substance extracted from birch bark, and which is now used to perfume Russia leather. When the fine white bark of the birch tree is distilled, it yields a light oil, nearly a quarter of which consists of the special phenol, or carbolic acid, which gives the well-known odour to Russia leather. It is now found that the residue, or green tar of the birch, which is obtained from Kostroma, yields neither acid nor alkaloid, and it forms, with alcohol, a solution of great fluidity, which, however, when once dried, is unacted upon by alcohol. It is this substance, which will unite with the most brilliant colours, that is used by Piron for treating textile fabrics. Not only does it fill the capillary vessels, but it also coats them with a varnish of great elasticity, which is unattackable by acids and sea water, while it also stands great changes of temperature. The aromatic odour of articles thus treated drives away insects; there is no space for microscopic vegetation, and neither air nor water can penetrate into the tissues. This process is applicable to all vegetable products, such as sailcloth, cordage, blinds, and awnings.

(12) Sackcloth or canvas can be made as impervious to moisture as leather by steeping it in a decoction of 1 lb. oak bark with 14 lb. boiling water. This quantity is sufficient for 8 yd. of stuff. The cloth has to soak for 24 hours, when it is taken out, passed through running water, and hung up to dry. The flax and hemp fibres, in absorbing the tannin, are at the same time better fitted to resist wear.

(13) Boiled oil, 15 lb.; beeswax, 1 lb.; ground litharge, 13 lb.; mix, and apply with a brush to the article, previously stretching against a wall or on a table, and well washing and drying each article before applying the composition.

(14) *Invisible Waterproofing for Clothing.*—Imbue the cloth on the wrong side with a solution of isinglass, alum, and soap dissolved in water, forming an emulsion of a milky thickness; apply with a brush, rubbing in well. When dry, it is brushed on the wrong side against the grain, and then gone over with a brush dipped in water; afterwards brushed down smooth.

(15) *Waterproofing Calico.*—Calico intended for an oilskin overcoat should be made up before it is oiled. The overcoat should be laid out on a

bench, and a coating of best boiled linseed oil applied sparingly all over with a brush; the coat is then hung in the open-air until the oil is quite dry, when it is again treated with oil and dried; three or four coats are thus applied. As a final coat, a layer of black paint thinned with turpentine may be put on. Oilskins are also made with raw linseed oil, and they are more flexible, but they take much longer to dry.

(16) *Waterproof Coat.*—Isinglass, alum, soap, equal parts; water sufficient. Dissolve each separately, and mix the solution, with which imbue the cloth on the wrong side. Dry, and brush the cloth well, first with a dry brush, and afterwards (lightly) with a brush dipped in water.

(17) *Waterproofing Paint for Van-covers, Horse-cloths, Capes, Leggings, Hats, etc.*—(*a*) Lampblack, ground in turpentine, ¼ lb.; ground black resin, 1 lb.; Brunswick black, 3 qt.; boiled linseed oil, 1 qt. Mix well, and when the resin is dissolved strain and it is ready for use. (*b*) Take ½ lb. camphor and 3 lb. garnet shellac, crush them and dissolve in 1½ gal. methylated spirit. Take ½ lb. vegetable black and 3 oz. Prussian blue, and rub these up in a little of the liquid mixture first described. When rubbed up to a paste add the rest of the liquid, and, when well mixed and strained, it is ready for use. Either of the above can be put up in 1 lb. tins for sale.

(18) *Seamen's Oilskins.*—The material should be fine twilled calico, dipped in bullocks' blood and well dried in a current of air, then two or three coats of raw linseed oil with a little gold size or litharge in it (say 1 oz. to 1 pint of oil). Each coat should be allowed to dry thoroughly before the next is put on (as before in a current of air, care being taken to shelter it from both sun and rain). Oilskins made in this way, both here and in the tropics, have stood for years.

(19) *Waterproofing Linen or Calico*—the manner in which sea-fishermen do coats and leggings.—Whatever the article is, let it be stretched on a table. Make very thick paint of whatever colour is wished. An invisible green is, perhaps, as good as any. Take a large lump of common brown soap, pretty freshly cut from a bar, in the left hand, and every time you replenish the brush with paint rub well on the soap, and take up as much as possible, and rub well on one surface of the calico or linen. It will take long to do, and should be hung in the windiest place you can find. Summer is the best time, but a month will see it in very usable order, and you will have as supple and perfectly waterproof a garment as paint can make. After wearing a few times a second coat would be advisable, which will dry in half the time of the first, and must be done in the same way.

(20) *For Canvas.*—A solution containing equal parts by weight of gelatine and chrome-alum. It is not advisable to mix more of the solution at ouce than is sufficient to give the canvas one coat, as, if the mixture once sets, it cannot be reliquefied like a plain solution of gelatine, and hence, if the quantity of canvas to be waterproofed is but small, it would, perhaps, be preferable to coat with plain gelatine solution until quite impervious to cold water, and then to thoroughly soak, say for 24 hours, in a strong solution of chrome-alum.

(21) *Sail-cloth.*—Grind 96 lb. English ochre with boiled oil, and add to it 16 lb. black paint. Dissolve 1 lb. yellow soap in one pail of water on the fire, and mix it while hot with the paint. Lay this composition, without wetting it, upon the canvas, as stiff as can conveniently be done with the brush, so as to form a smooth surface; the next day, or the day after (if the latter, so much the better), lay on a second coat of ochre and black, with a very little, if any, soap; allow this coat a day to dry, and then finish the canvas with black paint.

(22) *Woollens.*—Boil 4½ oz. white soap in 2½ gal. water, and separately

dissolve 5¾ oz. alum in 2½ gal. water. Heat the two solutions to 190°F. (88°C.), pass the fabric first through the soap bath and then through the alum, and finally dry in the open-air.

(23) *Oil-cloth.*—The manner of making oil-cloth or "oil-skin" was at one period a mystery. The process is now well understood, and is equally simple and useful. Dissolve some good resin or lac over the fire in drying linseed oil, till the resin is dissolved, and the oil brought to the thickness of a balsam. If this be spread upon canvas, or any other linen cloth, so as fully to drench and entirely to glaze it over, the cloth, if then suffered to dry thoroughly, will be quite impenetrable to wet of every description. This varnish may either be worked by itself or with some colour added to it: as verdigris for a green; umber for a hair colour; white-lead and lampblack for a grey; indigo and white for a light blue, etc. To give the colour, you have only to grind it with the last coat of varnish you lay on. You must be as careful as possible to lay on the varnish equally in all parts.

(24) A better method, however, of preparing oil-cloth is first to cover the cloth or canvas with a liquid paste, made with drying-oil in the following manner: Take Spanish white or pipe-clay which has been completely cleaned by washing, and, sifting it from all impurities, mix it up with boiled oil, to which a drying quality has been given by adding a dose of litharge, one quarter the weight of the oil. This mixture, being brought to the consistence of thin paste, is spread over the cloth or canvas by means of an iron spatula, equal in length to the breadth of the cloth. When the first coating is dry, a second is applied. The unevenness occasioned by the coarseness of the cloth or the unequal application of the paste are smoothed down with pumice, reduced to powder, and rubbed over the cloth with a bit of soft serge or cork dipped in water. When the last coating is dry, the cloth must be well washed in water to clean it; and after it is dried, a varnish composed of lac dissolved in linseed oil boiled with turpentine is applied to it, and the process is complete. The colour of the varnished cloth thus produced is yellow; but different tints can be given to it in the manner already pointed out. An improved description of this article, intended for printed and figured varnished cloths, is obtained by using a finer paste and cloth of a more delicate texture.

(25) *Varnished Silk.*—This material is prepared much in the same manner as (21), but with a paste composed of linseed oil boiled with ¼ part of litharge, 16 parts dried and sifted pipe-clay, 3 of litharge very finely ground, dried and sifted, and 1 of lampblack. After washing the silk, fat copal varnish is applied instead of that used for oil-cloth.

(26) *Waterproofing Silk.*—This may be done by applying a solution of paraffin in naphtha.

(27) *Linen.*—A solution of alumina sulphate in ten times its weight of water, and a soap-bath of the following composition: 1 oz. light-coloured resin and 1 oz. crystallised soda are boiled in 10 oz. water until dissolved. The resin-soap is precipitated with ¾ oz. table salt; and is subsequently dissolved along with 1 oz. white curd soap in 30 oz. hot water. It should be put in wooden tubs for use. On made up articles the two solutions can be applied with a brush and then rinsed off.

(28) Parone, of Turin, proposes the following method of rendering textures waterproof. In 14 pints of water heated to about 180° F. (82° C.) dissolve 10½ lb. gelatine and 21 lb. castor-oil soap; then add 10½ lb. lac, shaking the liquid till the lac is completely dissolved. Take it off the fire, and add to the mixture in small quantities at a time 21 lb. powdered alum, shaking it till the alum is dissolved. The liquid thickens, forming an insoluble alumina soap which remains closely incorporated with the gelatine and lac. It is spread over the textures with a brush.

(29) Cooley gives the following

recipe for waterproofing, which appears to have the advantage of having been tried with success:—"A simple method of rendering a cloth waterproof without being airproof, is to spread it on any smooth surface and to rub the wrong side with a lump of beeswax (perfectly pure and free from grease) until it presents a slight, but even, white or greyish appearance; a hot iron is then passed over it, and, the cloth being brushed whilst warm, the process is complete. When this operation has been skilfully performed a candle may be blown out through the cloth, if coarse, and yet a piece of the same placed across an inverted hat may have several glassfuls of water poured into the hollow formed by it, without any of the liquid passing through. Pressure or friction will alone make it do so."

(30) *Canvas.*—The following is highly recommended as a cheap and simple process for coating canvas for waggon tops, tents, awnings, etc. It renders it impermeable to moisture, without making it stiff and likely to break. Soft soap is dissolved in hot water and a solution of iron sulphate added. The sulphuric acid combines with the potash of the soap, and the iron oxide is precipitated with the fatty acid as insoluble iron soap. This is washed and dried and mixed with linseed oil. The soap prevents the oil from getting hard and cracking, and at the same time water has no effect on it.

(31) Waterproofing Oil.—Take 20 oz. lard oil, 10 oz. paraffin, 1 oz. beeswax; heat the oil over a slow fire, and when hot add the paraffin and wax; allow the whole to remain over the fire until the latter articles are melted, and add a few drops of sassafras oil or other essential oil to preserve it.

(32) *Sailcloth Impervious to Water, yet Pliant and Durable.*—Grind 6 lb. English ochre with boiled oil, and add 1 lb. black paint, which mixture forms an indifferent black; 1 oz. yellow soap, dissolved by heat in ½ pint water, is mixed while hot with the paint. This composition is laid upon dry canvas as stiff as can conveniently be done with the brush. Two days after, a second coat of ochre and black paint (without any soap) is laid on, and, allowing this coat time to dry, the canvas is finished with a coat of any desired colour. After three days it does not stick together when folded up. This is the formula used in the British Navy yards, and it has given excellent results. A portable boat may be made of canvas prepared in this way, and stretched on a skeleton frame.

(33) *Woollen Cloth.*—4 oz. powdered alum, 4½ oz. sugar of lead, dissolved in 3 gal. water, and stirred twice a day for two days. When perfect subsidence has taken place, pour off the clear liquid only, and add to it 2 dr. isinglass, previously dissolved in warm water, taking care to mix thoroughly. Steep the garments in this mixture for six hours, after which hang up to drain and dry. Wringing must be avoided. This recipe is used by woollen-cloth waterproofers.

(34) Dujardin's process for all kinds of textiles is as follows. Place in a mortar 12 oz. alumina and potash sulphate reduced to powder, and 12 oz. lead acetate; bray till the mixture is quite deliquescent. Add 7 oz. pulverised potash bicarbonate, and 7 oz. soda sulphate; bray till completely combined. Pour in 4¼ oz. calcined magnesia, and continue braying while adding 8¾ pints water. Pour the whole into a bucket containing 11 gal. river or rain water, which must be fresh. Shake the whole until there is complete solution, which takes place in 20 minutes. Pour the liquid thus obtained into a convenient receptacle holding about 22 gal., in which have been dissolved 5¼ lb. oleine soap in 11 gal. rain or river water. Boil for about 20 minutes. To render a texture waterproof, it is then sufficient to put in this liquid either by hand or machinery until it is perfectly impregnated in all its parts. Care must be taken during the whole operation to stir the mixture well, that no deposit may be

formed. The texture is then withdrawn, left to drip, and dried. It is afterwards washed in plenty of water, dried, and dressed as usual. In this condition the texture is waterproof, but penetrable by air, which is indispensable for health. This process does not alter tints at all, but if the materials have very delicate tints, it is necessary to take account of the composition of these colours, and compose the bath accordingly. The potash bicarbonate and soda sulphate must then be sometimes replaced by the same quantity of salts of iron, copper, zinc, lead, or some other metallic salt suitable for preserving colours. To prepare linen, leather, or wood, add 3½ oz. margarine to the bath. When it is desired to prepare cotton or paper, it is well to add to the bath 1¾ oz. gelatine, and 3½ oz. light-coloured rosin. After that, dry in the open air or at the fire, and the products will be perfectly impermeable, and resist every kind of washing. Paper paste may be even soaked in the vat, and thus an impermeable paper obtained, the above process replacing the sizing.

Brickwork.—To exclude dampness, use the following: ¾ lb. mottled soap is dissolved in 1 gall. boiling water, and the hot solution spread steadily with a flat brush over the outer surface of the brickwork, care being taken that it does not lather; this is allowed to dry for 24 hours, when a solution, formed of ¼ lb. alum dissolved in 2 galls. water, is applied in a similar manner over the coating of soap. The soap and alum form an insoluble varnish, which the rain is unable to penetrate, and this cause of dampness is thus said to be effectually removed. The operation should be performed in dry, settled weather.

Another method is to use 8 parts linseed oil and 1 part sulphur, heated together to 278°, in an iron vessel.

Buildings.—*Composition of some of the Waterproofing Compounds in Use.* In the "Sylvester's process" a hot solution of soap, prepared by dissolving ¾ lb. of Castile soap in 1 gall. of water is first brushed over and into the surface of the concrete, and allowed to dry for 24 hours. At the end of that period a second wash, consisting of 2 oz. of alum dissolved in 1 gall. of water, is applied in the same manner. The alum solution should be at a temperature of from 60° to 70° F. The double operation is to be repeated as often as necessary or desirable, but four such coats are said to be impervious to a head of 45 ft. of water.

In "Handbook for Superintendents of Construction, etc.," the following cement wash is recommended for making a water-tight lining for cisterns: A stock solution is prepared of 1 lb. "lye," 5 lb. alum dissolved in 2 qt. of water. One pint of this solution is stirred into a pail of water containing 10 lb. of cement, and the mixture is applied to the surface of the concrete with a brush.

Another method is to apply a rendering composed as follows:

1. Portland cement 1 part, sand 1 part.
2. Portland cement 1 part, sand 2 parts, lime paste ½ part.
3. Portland cement 1 part, sand 3 parts, lime paste 1 part.
4. Portland cement 1 part, sand 5 parts, lime paste 1½ part.

The surface of the rendering, composed according to one of the above formulas, is brushed with a solution of 1 lb. "concentrated lye," 5 lb. alum, and 2 gall. water, in the proportion of 1 pint of this solution to 5 lb. of cement.

In principle the above-named methods are alike, and all depend upon the precipitation within the surface pores of the concrete, or outer coat, of insoluble alum soap, or hydrate of alumina, or both together. The last-named example, however, combines to some extent the method of pore-filling in bulk with sand and lime paste.

In "Plastering, Plain and Decorative," Miller recommends painting the surface of the work with a hot mixture prepared by mixing 20 lb. of chopped suet with 1 bushel of lime, and stirring up with boiling water.

Professor Hatt states that with a mortar composed of 1 part of cement to 2½ parts of bituminous ash, when alum and soap were mixed with the water used for gaging, the strength and hardness increased 50 per cent., and absorption decreased by the same amount. One half of the water used for gaging was a 5 per cent. solution of ground alum, and the other half was a 7 per cent. solution of soap. The alum solution was used first.

Cunningham proceeds on similar lines. He uses powdered alum equal to 1 per cent. of the combined weight of sand and cement. To the water used in the mix he adds 1 per cent. of yellow soap.

Hawley employed a stock solution of 2 lb. caustic potash, 5 lb. powdered alum, and 10 qt. water. A finishing coat was made with 3 qt. of this solution in each batch of mortar containing 2 bags of cement. The mortar was made with 2 volumes of sand to 1 of cement, and the work covered to a depth of ½ in.

Marsh gives the following as a waterproof coat or rendering: 2 lb. soft soap, 12 lb. alum, 30 gall. water per cub. yd. of the mortar. Or, 2 lb. caustic potash, 5 lb. alum, 10 quarts water. Of this solution 3⅔ quarts are used for two bags of cement and twice its volume of sand.

It will be observed that these processes again depend upon the precipitation of aluminium soap or hydrated oxide of aluminium, the only difference being that, in these cases, the precipitate is mixed with the mortar instead of being deposited at the surface of the hardened material.

Gaines, in a paper recently published, states that watertight concrete can be made (1) by replacing the mixing water with a dilute solution of a suitable "electrolyte" (i.e., a 1 per cent. or 2 per cent. solution of alum); (2) by replacing 5 per cent. to 10 per cent. of the cement with dried and finely ground colloidal clay; (3) by combining methods (1) and (2). With regard to the second of these processes, the action appears to be simply one of pore-filling with fine particles of clay, inasmuch as no "electrolyte" is used; and in the other cases it is probable that the same kind of action takes place by precipitation of alumina, from the "electrolytic" solution, by calcium hydroxide, whether the electrolytic theory itself be correct or not.

It may be remarked that the use of pulverised clay for this purpose is old.

"'Lux," Patent No. 4606 of 1904. This material is prepared by pouring over 100 kilos. of cement clinker (unground) 10 litres of boiling water containing 245 grams of stearine, 12 grams of potash (presumably caustic potash, although it is not clearly stated), and 10 grams of colophony (i.e., common resin).

Gallagher's Waterproof Compound. This material is to be added to cement in the proportion of 2 per cent. to 5 per cent. on the weight of dry cement before mixing with the sand and water. Its composition has been stated to be chiefly lime and magnesia, with about 3 per cent. of stearine or other fatty acid.

"Pharos" waterproofing compound is composed of the following:

LIME SOAP.

	Per cent.
Free fat (tallow or stearine)	20·22
Combined fatty anhydrides	14·55
Combined lime	1·57
Lime	30·45
Magnesia	21·15
Hygroscopic water . . .	3·32
Combined water. . . .	5·77
Silica	1·17
Alumina and ferric oxide .	1·18
Sulphuric anhydride, etc. .	0·62
	100·00

Cold bituminous dampproof paints, such as Horn's Dehydratine, Toch's R.I.W., Antihydrine, etc., for use on the interior surfaces of exposed walls or for exterior of foundations not subject to water-pressure. These are made up of specially selected asphalts dissolved in carbon bisulphide or some kindred hydrocarbon, the proportions varying according to the use to which same is to be put.

Paraffin, or other mineral substances, dissolved in gasolene with the addition of resin as a hardening agent, proportions varying according to use. This is employed for surface application to walls, etc., that are to be rendered watertight. Trade names: Dehydratine, Waxol, Anhydrol, etc.

Hydratite, Medusa, Maumee, Whitehall, Toxement, etc., and similar powders in very finely divided state. These are metallic stearates to which are added varying proportions of hydrated lime, alum and clay; 2 per cent. of the compound is usually added to one bag of cement before the addition of water.

* * *

WEED KILLERS.

(1) 1 lb. white arsenic (the common commercial kind), ½ pint vitriol, 1 gal. boiling water; mix. Take one pint of above and mix it in 3 gal. of water, and apply with a water-can. Take care not to let any go on plants, box-edging, etc., as it is as fatal to these as to weeds. Do not walk on the path while it is wet, and then walk on grass, or the grass will be killed where the wet poison-laden boots press. The above is a strong poison, therefore use care in keeping it, also in washing out the can after use.

(2) Used by the authorities in Paris. Stone lime 10 lb., flour of sulphur 1 lb., water 5 gal. Boil in an iron vessel, allow it to settle, then, when cold, use the clear part. This is destructive to box-edging, flowers and grass lawn, if it gets on them.

(3) Arsenic alone, as (1), without vitriol, is a weed-killer. To prevent it being taken for water it can have soot put in it, or a little carbolic acid, or creosote oil. Both the latter are weed killers.

(4) ½ pint sulphuric acid (vitriol) to six pails of water. Mix acid in slowly.

(5) 1 part of weak ammoniacal liquor to five parts of water.

(6) Chloride of lime sprinkled on the weeds.

* * *

WHITEWASHING AND DISTEMPERING.

Whitewashing and Lime-Whiting.—(1) This is most commonly applied to ceilings and walls. If the ceiling is new, nothing further is required than a coat of good Paris white (whiting of a superior kind), with just sufficient glue size added to bind it, provided the finishing plaster is of good workmanship; but if inferior and very porous, it will require a preparation of strong size, soft soap, and a handful of plaster of Paris. For old ceilings, all the previous whiting, etc., must be thoroughly washed off with an old whitewash brush and hot water, and allowed to dry before re-whitening. When this is done, if the ceiling is 'hot"—i.e., porous, and soaks in the moisture very quickly—it must be prepared with a mixture of lime, one handful; whiting, the same; glue, ½ lb.; soft soap, ¼ lb.; and if smoky or damp, about 2 oz. alum, to make a pail ¾ full. When this is dry, it is ready for the finish. Use the preparation thin. To prepare whitewash properly, the whiting should be soaked overnight in plenty of water, thoroughly stirred up to wash it, and allowed to settle till the morning, when all the water possible should be drained off. The size should likewise be melted the night before use, so as to be jellied in the morning. It works better when cold. About ½ lb. size is required to 1 gal. water, which, with the water taken up by the whiting, will make it ready for use. Before using, the size and whiting should be broken up separately and strained through a fine sieve; then mixed and strained again. Before putting on the whiting, shut all doors and windows to exclude the draught, take a sweep right across the room, and continue till finished. If two are engaged at it, so much the better, as it requires to be done quickly; be careful to cover well, or you will not make a nice job. When finished, the doors and windows can be opened, as the sooner it dries after it is once on the more even and solid it will look.

For whitening and colouring walls, great care is required in preparing them; all the old stuff must be cleared off, well rubbed down with dry lump pumice, all holes well and evenly stopped with plaster of Paris, and a preparation of strong size, whiting, and alum, thickly laid on, of the colour you are going to finish, but a little darker in shade. When this is well dry, rub it well down to a good level and smooth face with lump pumice or coarse sandpaper. The finishing coat may be made in the same way as for the ceilings; but if exposed to the liability of being touched or rubbed against, a little more or stronger size is to be used; and if in any way too damp, a little alum. To get any of the colours required, it is merely necessary to get the dry powders and rub up with the whiting, prior to mixing with size, adding by degrees till the required depth of tone is arrived at. For the different shades of drab or stone-colour, yellow ochre, umber, black, and red are used. For shades of blue, from the French grey to sky blue, ultramarine, etc. (*'Painting for the Million.'*)

(2) If glue is employed to give body, it is destroyed by the corrosive action of the lime, and in consequence the latter easily rubs off the walls when dry. This is the case also if the lime is employed, as is often absurdly recommended, simply slaked in water, and used without any fixing material. Lime-wash is prepared by placing some freshly-burned quicklime in a pail, and pouring on sufficient water to cover it; boiled oil (linseed) should then be immediately added, in the proportion of 1 pint to 1 gal. of the wash. For coarser work, any common refuse fat may be used instead of the boiled oil. The whole should then be thinned with water to the required consistency, and applied with a brush. Care should be taken not to leave the brush in the lime-wash for any length of time, as it

destroys the bristles. In lime-washing, Russia tallow is frequently used in preference to any other fatty matters. (*Tegetmeier.*)

(3) No brick wall that ever is intended to be painted should be whitewashed. All washes absorb water, and in damp weather lose their colour. For one barrel of colour wash take ½ bushel white lime, 3 pecks hydraulic cement, 10 lb. umber, 10 lb. ochre, 1 lb. Venetian red, ¼ lb. lampblack. Slake the lime, cut the lampblack with vinegar, mix well together, add the cement, and fill the barrel with water. Let it stand for 12 hours before using, and stir frequently while putting it on. This is not white, but of a light stone colour, without the unpleasant glare of white. The colour may be changed by adding more or less of the colours named, or other colours. This wash covers well, needing only one coat. A rough board barn washed with this will look well for 5 years, and even longer, without renewing. The cement hardens, but on a rough surface will not scale. ('Scient. Amer.')

(4) A wash which can be applied to lime walls and afterwards become waterproof so as to bear washing. Resenschek, of Munich, mixes together the powder from 3 parts silicious rock (quartz), 3 parts broken marble and sandstone, 2 parts burned porcelain clay, with two parts freshly slaked lime, still warm. In this way a wash is made which forms a silicate if often wetted, and becomes after a time almost like stone. The four constituents mixed together give the ground colour to which any pigment that can be used with lime is added. It is applied quite thickly to the wall or outer surface, let dry one day, and the next day frequently covered with water, which makes it waterproof. This wash can be cleansed with water, without losing any of its colour; on the contrary, each time it gets harder, so that it can even be brushed, while its porosity makes it look soft. The wash or calcimine can be used for ordinary purposes as well as for the finest painting. A so-called fresco surface can be prepared with it in the dry way.

(5) Well wash the ceiling by wetting it twice with water, laying on as much as can well be floated on, then rub the old colour up with a stumpy brush and wipe off with a large sponge. When this is done, stop all the cracks with whiting and plaster of Paris. When dry, claircole with size and a little of the whitewash. If very much stained when this is dry, paint those parts with turps, colour, and, if necessary, claircole again. To make the whitewash, take 12 lb. whiting (in large balls), break them up in a pail, and cover with water to soak. During this time melt over a slow fire 4 lb. common size, and at the same time, with a palette knife or small trowel, rub up fine about a dessert-spoonful of blue-black with water to a fine paste; then pour the water off the top of the whiting, and with a stick stir in the black; when well mixed, stir in the melted size and strain. When cold it is fit for use. If the jelly is too stiff for use, beat it well up and add a little cold water. Commence whitewashing over the window, and so work from the light; lay off the work into that done, and not all in one direction, as in painting. Distemper colour of any tint may be made by using any other colour instead of the blue-black — as ochre, chrome, Dutch pink, raw sienna for yellows and buff; Venetian red, burnt sienna, Indian red, or purple-brown for reds; celestial blue, ultramarine, indigo, for blues; red and blue for purple, grey, or lavender; red-lead and chrome for orange; Brunswick green for greens. (Smither.)

(6) ½ doz. balls of whiting, 2 lb. size, and 1 oz. celestial or ultramarine blue; this will cover about 12 sq. yd. Mixing: Take the whiting and break up in just enough water that you can work it about in a bucket with a stout stick. Next take a saucepan, about 3 qt., and put a pint of water in and boil; take off the fire, and drop your size into it, and let it stand upon the hob until melted. When tolerably

warm, pour into your whiting, being careful to keep stirring it. Mix up your blue with a flat stick upon a slate or board, and add until it becomes of the shade required.

Lime that will produce a fast limewash is burnt in the bottom of brick kilns, the bricks upon the top, and fired with heath, fir loppings, coal, wood, ferns, and gorse. The sand from the bricks, the chalk, and the potash from the wood combined, cover the chalk or lime with a silicate soluble in water. To use this, get it fresh burnt, break it up, and pour boiling water upon it; it subsides into a beautiful cream-like consistence. This, owing to the soluble silicate in it, must be made and used fresh. It is fast, and frequently prevents a glazed surface, and, if not put on too thick, is very durable. A peck of lime will do about 20 sq. yd.

(7) Lime is always apt to turn a bad colour. The way to *whitewash* a ceiling is to first thoroughly wash with clean water—not one pail, which speedily gets dirty, but with several. Then steep balls of whiting in water, and the next day reduce them to a thick cream. Put a kettle on the fire, with sufficient size, and when hot pour it on the whiting, adding at the same time some finely-ground blue-black. The proportions are, say, 6 balls whiting, 2 lb. size, and ½ to 1 oz. of blue-black, according to taste. The mixture must be allowed to cool before using. To *limewash*, clean first, and then proceed to make up the following: Take ½ bushel lime, and slake it; add 1 lb. common salt, 1 lb. white vitriol, and 1 gal. skim milk. With a clean surface this will not shell off, neither will limewash and size, when properly prepared and laid on a clean surface.

(8) Recommended by the United States Treasury Department to all the lighthouse keepers; it answers for wood, brick, or stone: Slake about ½ bushel unslaked lime with boiling water, keeping it covered during the process. Strain it, and add 1 peck salt dissolved in warm water, 3 lb. ground rice put in boiling water and boiled to a thin paste, ½ lb. powdered Spanish whiting, and 1 lb. clear glue dissolved in warm water; mix these well together, and let the mixture stand for several days. Keep the wash thus prepared in a kettle or portable furnace, and when used put it on as hot as possible with either painters' or whitewash brushes.

(9) Having prepared the ceilings, scraped them, washed them, or removed the blisters and inequalities, use any of the following, according to the kind of job operated on: (*a*) Well-selected pieces of quicklime, free from the appearance of iron (avoid red streaked); slake with water; when all have fallen to powder, mix to proper consistency, and apply with a stock brush, about 6 in. broad; this is suitable for common purposes. (*b*) Common whiting, washed whiting, Paris whiting (or gilders' white), mixed with water and a little size (strong glue boiled down); these are suitable for all parts of a house, from the kitchen to the drawing room. (*c*) For a superior job, and where there is much gas burnt, use white oxide of zinc in water, and a little size; this will keep beautifully white a very long time, but is dear. In some cases it is desirable to first paper the ceiling with ceiling-paper before whitewashing. Considerable practice is necessary to lay on the wash quite even. Be careful not to leave clouds or tails where the brush leaves the surface after the stroke, and above all see that the ceiling is not dusty. (Kemp.)

Distempering.—There are comparatively few painters who are thorough masters of the apparently simple process of distempering. It depends upon so many conditions that it is often very difficult indeed for the most experienced workman either to satisfy himself or his employers. And when failure does result, it is not always that the cause can be readily defined and a remedy applied. This may be, and probably is, due in a great measure to a want of chemical knowledge, by which alone the "why" and the "wherefore" are elucidated. But whatever may be the cause, certain it is that painting in distemper colours is not always satisfactory. But when skilfully executed, distemper work is much lighter and purer in tone than painting in oil colours. The whiteness, for instance, of distemper work is purer than the whiteness of oil colour, and any tint that the distemper may be made to partake of, will, accordingly, as compared with the corresponding tint in oil, be purer also. It will, however, be obvious that distempering, whatever may be its advantages in this respect, is not suitable for use on interior walls which are liable to suffer from contact, or which are subject to rough usage. In these cases flatting is absolutely essential, unless, indeed, the more prevalent practice of covering the walls with paperhangings is adopted.

It has been truthfully observed by a writer on this subject that the preparation of ceilings and walls for the finishing of distemper is of vital importance to the ultimate result, inasmuch as if they are not properly prepared they will rarely turn out well at the finish. The first thing is to stop the suction, for except the finishing colour lays on cool, and without any or very little suction, the work is apt to be more or less rough, and will gather or accumulate more colour in one part than in another, and consequently will look shady. And here we may note a fact which shows the necessity for the use of a preparation. It will almost invariably be found that one part of a wall or ceiling will have a greater power of absorbing colours than another part. It will be observed, as with a first coat of paint, that some parts are glossy and others dry dead—that is, the paint has sunk into or been absorbed on the dead parts, while on the glossy part it remained on the surface, owing to the unequal finish of the plaster work. Of course, in oil painting this is remedied by successive coats of paint. It therefore becomes necessary that means be adopted to stop this power of absorption when distempering, and for this purpose various preparations are used. The following has been recommended as a suitable preparatory coat, and will be found to answer the purpose very effectually: "Mix about a dozen pounds of the best whiting with water to the consistency of soft paste; add sufficient parchment or other size to bind the colour fast; add about 2 oz. of alum, and the same weight of soft soap dissolved in water; mix well together in a pail and strain through a coarse cloth or metal strainer." Of course, somewhat similar proportions will answer for any quantity. The colour should now be tried on paper, and dried before a fire or otherwise, in order to test whether sufficient size has been used to "bind" the colour, and to prove that the tint is exactly what is required. The finishing coat can be laid on without disturbing the first one. The alum and soft soap contribute to this effect in a great degree, and help to form a semi-impervious coating upon which the finishing coat will work cool and without suction. Caution must be observed not to have the size too strong, or it will be very liable to chip, especially in rooms where much gas is used.

We quote the following from the pen of "An Experienced Workman," and have to observe that the directions given are thoroughly trustworthy: "In order to produce good work, two things are necessary in the mixing of distemper—namely, clean and well washed whiting and pure jellied size. The whiting should be put to soak with sufficient soft water to cover it well and penetrate its bulk. When the whiting is sufficiently soaked, the water should be poured off, which will remove any dust or foreign matter from the whiting. It should then be beaten up or stirred until all the lumps are broken, and it becomes a stiff, smooth, paste. A good workman will do this carefully with his hand, and will manipulate it until it is quite smooth, but it may be done most effectually with a broad stick or spatula, and then strained through a metal or other strainer.

The size should now be added, and the two lightly but effectually mixed together. Care should be taken not to break the jelly of the size any more than can be avoided, and this may be best done by gently stirring the mixture with the hand. If the jellied state is retained intact, the colour will work cool and lay on smooth and level. Then size, whether made of parchment chippings, glue or any other material, should be dissolved in sufficient quantity of water to form a weak jelly when cold. In practice, we find that distemper mixed with jellied size will lay on better and make a better job than when the size is used hot. Colour mixed on the former plan works cool and floats nicely, while the latter works dry and drags and gathers, thus making a rough ceiling or wall, and the difference in the labour required is very much in favour of the jellied size. A little alum added to the distemper has a good effect in hardening, and helps it to dry out solid and even."

It is customary in some cases to give the ceiling or wall a couple of coats of oil paint previous to the application of the distemper. This stops the suction and gives a richness to the colouring; but if, as frequently happens, the wall gets low in temperature during a continuance of cold weather, when a change takes place the condensation is so great that the water runs down in streams to the top of the skirting, and the colouring matter thereby becomes stained.

The following hints for mixing various colours in distemper, etc., by which, at least, a theoretical knowledge of the subject can be acquired, will greatly facilitate progress in mastering the practical details.

The best size for distemper colours is made from parchment clippings. These are put in an iron kettle filled with water, and are allowed to stand 24 hours, until the pieces are thoroughly soaked; then boil for 5 hours, occasionally taking off the scum. When the liquid is sufficiently boiled, take it from the fire and strain it through a coarse cloth. If the size is to be kept a length of time, dissolve 3 or 4 oz. of alum in boiling water and add to every pailful. The size must be boiled again till it becomes very strong. It must then be strained a second time, put into a cool place, and it will keep for several weeks. Different kinds of size are sold at the colour shops, some of which are exceedingly pure and may be depended upon for general purposes.

Pink.—Dissolve in water separately whiting and rose pink. Mix them to the tint required, strain the colour through a strainer, and bind with size.

Lilac.—Take a small quantity of indigo, finely ground in water, and mix it with whiting till it produces a dark grey; then add to the mixture some rose pink. Well mix and strain the colour, and a beautiful lilac will result.

Light Grey.—A small quantity of lampblack mixed with whiting composes a grey. A wide range of shades may be obtained, from the darkest to the lightest grey.

French Grey.—Take the quantity of whiting required and soak it in water, then add Prussian blue and lake which have been finely ground in water. The quantity of each of those colours should, of course, be proportioned to the warmth of the tint required. This is a handsome and delicate colour for walls. Rose pink may be substituted for the lake, but it does not make so brilliant a colour—neither is it so permanent.

Orange.—This is a mixture of whiting, Dutch pink and orange leads. These ingredients may be proportioned according to taste. This colour cannot be worked except in a size jelly, as the orange lead is a colour which has great density, and will sink to the bottom, separating from the other colours.

Buff.—A good buff may be produced by dissolving separately whiting and yellow ochre in water. A little English Venetian red should be added to give a warm cast. Mix with size, and strain as before directed.

Drab. — (1). Dissolve whiting in water, and grind some burnt umber very fine in water. Mix to the tint required. Raw umber will make a drab of a different shade. (2) Dissolve separately some whiting and yellow ochre in water. Take a quantity of each and mix them together. Grind a little lampblack very fine, and with it sufficiently stain the colour to make the tint required. (3) Another shade may be obtained by adding a little Venetian red. By diversifying the proportions of these pigments a great variety of colours may be produced. These are all permanent colours, and may be depended upon.

Salmon.—An excellent salmon colour may be made by dissolving whiting in water, and tingeing it with the best English Venetian red. A little Venetian red mixed with lime whitewash and a quantity of alum, will answer very well for common purposes.

Laying on Distemper Colours.—With regard to this, it may be accepted as a fact that the sooner they dry after they are laid on the better. The best plan is to close the windows and doors and stop the free circulation of the air as much as possible while the distemper colour is being laid on. This prevents it drying too quickly, and enables the workman to lay the colour on more evenly and with less danger of showing any piecings; but the moment the wall or ceiling is covered, the windows and doors should be thrown wide open and as much fresh air admitted as possible. This free circulation of air absorbs and carries off the moisture from the walls. The evaporation is quick, and a good job results. If the distemper does not dry quickly it becomes slightly discoloured and shaded. One great point to be aimed at is, of course, a level and uniform surface when dry, and this desirable result can only be obtained by the colour being laid on of a proper consistency, and with every attention to quality.

To whiten walls, scrape off all the old whitewash, and wash the walls with a solution of 2 oz. of white vitriol to 4 gal. of water. Soak ½ lb. of white glue in water for 12 hours, strain and place in a tin pail; cover with fresh water, and set the pail in a kettle of boiling water. When melted, stir in the glue, 8 lb. of whiting, and water enough to make it as thick as common whitewash. Apply evenly with a good brush. If the walls are very yellow, blue the water slightly by squeezing in it a flannel blue-bag.

Soft and pleasing ornament may be executed upon distemper grounds by using such transparent water pigments as the siennas, indigo blue, umber, Italian and rose pink, in the form of washes or glazes. Beat up the white of an egg and dilute with an equal quantity of water; this will make an excellent medium for any water pigment. After the design is stencilled make a dark brown outline colour, from Vandyke brown and madder lake, for instance, using the egg vehicle still, and with this pencil up the ornament or outline it as may be necessary.

For wall colours, greys, greenish grey, or deep reds are suitable. Mr. W. Morris, in a list of wall colours, recommended a solid red, not very deep, but rather describable as a full pink, and toned with yellow and blue; a light orange pink to be used sparingly; a pale golden tint (yellowish brown), a very difficult colour to hit; a pale copper colour between these two; tints of green, from pure and pale to deepish and grey, always remembering that the purer the paler, and the deeper the greyer. These are all tried and artistic colours. Perhaps a terra-cotta red or pink is one of the most useful colours for halls and the dados of dining-rooms and staircases, where there is plenty of light. Tints of grey, from bluish to greenish tones, are suitable, and a salmon colour is effective in a room full of cold light. (‘*Master Painter*.’)

When ceilings are badly stained and discoloured from the accidental overflow of cisterns, water closets, etc., the only effectual way of treating them is to wash them off with clean water and give two coats of oil paint before the distemper is applied. Other processes are adopted, but as they cannot be depended upon, it is much better in the first instance to incur a little extra expense and paint the discoloured ceiling in oil colours. ('*The Western Painter.*')

Stained ceilings, caused by water having soaked through them, may be remedied by a simple plan. Take unslaked white lime, dilute with alcohol, and paint the spots with it. When the spots are dry, which will be soon, as the alcohol evaporates and the lime forms a sort of insulating layer, one can proceed painting with size colour, and the spots will not show through again.

Glycerine in distemper colours fits them for working on metal. A little glycerine added to distemper will retard its drying, and this is very useful in hot weather. Before attempting to apply distemper colours, the ground upon which you are to work should be perfectly clean. Colours for tinting should be put on warm : 1 oz. of glue and ¾ lb. of dry colour give a mixture that will hold well.

Distemper painting when dry always comes out much lighter than when first applied. This fact must be borne in mind when one is matching colours.

When it is desired to match the colours of wall-paper in distemper colours, in order to get a perfect match it is well to wet the paper and to match it while in that condition. Of course, both paper and colour will lighten up considerably on drying.

Gloss in white ceilings should be avoided. It can be obtained by using an excess of size, but the wash so prepared is very liable to crack and peel off.

Many new ceilings are whitened before they are dry, with the result that they have a smeary appearance when finished. If there is any sign of moisture on a ceiling, it is not in a proper condition to be whitened. We have seen a good mottled effect produced on a frieze, to which had been given a body of rich yellow, gold bronze, with decoration in water-colour of mingled purples put on with a coarse sponge rolled over the surface.

Among the colours upon which lime has no bad effect, and which may therefore be employed with safety for water-coloured ceilings, walls, etc., are siennas and umbers, Vandyke brown, ivory black, Naples yellow, French ultramarine, and Chinese vermilion.

For church walls a rough floated surface is best for distemper. Stippling the wall surface is a method sometimes used for fine work, by treating the walls with the butt of the bristles. A solid effect is obtained by the process if a full coat of colour is given first.

Kalsomining a white wall is one thing, and tinting a wall is quite another. One may patch up the defects in the wall as he goes along with plaster of Paris or thick kalsomine, in the first instance, but in tinting in colours the wall must be prepared and thoroughly dry before tinting is applied.

When hard-finished walls have been kalsomined, the soiled coats should be washed or scraped off before a new one is put on. This is the most disagreeable part of the process. The furniture should be covered, as the lime makes spots that are removed with difficulty, especially on black walnut.

When a ceiling is simply tinted, the tint should be one that softens into the wall-paper or wall colour—not one that contrasts. Thus, if the tone of the room is that of a soft grey-blue, the ceiling should be of a clear flesh pink ; or should a grey-green be picked out with black—a lemon colour will be appropriate for the ceiling.

A distemper medium, described by Le Coudron, consists of soft soap, 57 oz. ; mucilage, 1 gal. ; oil of myrbane, ½ pint ; salicylic acid, 8 oz. ; glycerine, 3 pints ; water, 1 to 2 pints ; mixed cold and allowed to stand several days, then run through mill. Dry colours—about 1½ lb. to the pint—are added at will and incorporated by regrinding.

A patch or hole, freshly filled and tinted, will always come out a brighter shade than the balance of the wall. If you colour your filling matter with the same stuff you are tinting with, it will turn out darker. A patch put on with more lime than is contained in the balance of the wall will turn out darker. It is advisable to size the first with vinegar, the latter with glue. Black, greasy, or smoked walls should be cleaned with a stiff brush and sized with an alkali like pearline. Sal-soda is too severe on a brush.

Distemper (Water Colour) Paints, or Colour Washes.—The basis of distemper paints is well washed whiting and suitably prepared size, as is described later. The following are colouring mixtures only.

French Grey.—Use a little Prussian blue for a blue tint, or a little lake for a warm tint, or the two may be used together.

Light Grey.—A small quantity of lampblack and Prussian blue.

Lilac. — Indigo, finely ground in water. Add this to the whiting until it is a dark grey, then add sufficient rose pink.

Pink.—Rose pink.

Salmon.—Venetian red (ground in water).

Terra-Cotta.—Venetian red and a little ochre.

Straw. — Chrome yellow or Dutch pink.

Buff.—French yellow and Venetian red.

Orange.—Green copperas dissolved in hot water.

Primrose. — Lemon chrome or chrome yellow.

Green.—Green verditer and mineral green.

Cherry-wood.—Burnt sienna and raw sienna.

Brick Red.—Venetian red and yellow ochre.

Washable Distempers.—FOR INTERIOR USE.—(1) 30 lb. plaster of Paris, ½ lb. dextrin, 2 lb. casein, 2½ lb. gum arabic, ½ lb. borax. Dissolve the casein, dextrin and gum in boiling water, and add the borax. This should be allowed to stand a day or two, when it will appear like a thick size. It is now a stock material ready for use, and can have keeping qualities given it by adding, with the borax, an ounce of carbolic acid. When required for use take a suitable quantity, add plaster of Paris and boiling water to the suitable consistency. Colouring matter may be added as required.

(2) 6 lb. plaster of Paris, 2 lb. slaked lime, 1 lb. zinc-white, ½ lb. pale glue size, ¼ lb. gum arabic, ¼ lb. alum, ¼ lb. borax. One pint of boiling water to each pound of dry sifted mixed material. When cool add cold water as required. The zinc-white is what may be termed the colouring material, and may be replaced with any other colouring ingredient that will withstand lime. These are Venetian red, Indian red, red oxide, madder, burnt sienna, vermilion, yellow ochre, zinc chrome yellow, ultramarine, lime blue, emerald, lime green, raw umber, burnt umber, Vandyke brown.

(3) 5 lb. whiting, 5 lb. white china clay, ½ lb. casein, 10 lb. silicate of soda. Mix with water.

Dry Washable Distemper.—(1) 20 lb. Paris white, 6 lb. plaster of Paris, 6 lb. zinc-white, 6 oz. borax, 3 oz. alum, 1½ lb. palest dextrin, ½ lb. gum arabic. Powder and sift the gum, alum and Paris white, then mix the whole and sift finely. This can be stocked in powdered form and any dry colour added (see preceding recipe) as required. For use add 1 pint of boiling water to 1 lb. of powder. When dissolved and cool add more cold water as required. For brown or dark tinted distempers the dextrin need not be of the pale quality, which is dearer than the brown.

(2) 28 lb. of whiting, 28 lb. of Paris white, 28 lb. slaked lime, 4 lb. casein, 4 lb. glue, 5 lb. alum, 8 lb. silicate of soda. Tint as already described. Mix with water.

FOR EXTERIOR USE.—(1) 1½ cwt. plaster of Paris, 10 lb. casein, 2 lb. dextrin, 8 lb. gum arabic, 2 lb. silicate of soda, 7 lb. slaked lime, 2 lb. borax, 2 oz. carbolic acid. Dissolve the gum, casein and dextrin in boiling water, add the borax and carbolic acid; then, when required for use, add the plaster of Paris and cold water, and any colouring ingredient required.

(2) 40 lb. lime slaked to a cream and strained, 25 lb. whiting, 2 gal. linseed-oil, 2 lb. alum, 8 lb. glue dissolved to a size. Mix with water.

(3) 40 lb. lime slaked to a cream, 20 lb. whiting, 20 lb. Paris white, 2 gal. linseed-oil, 4 gal. skimmed or separated milk, 2 lb. alum, 8 lb. glue dissolved to a size. Tint as required, as already explained.

(4) Put in a tub or barrel 1 bushel of quicklime and slake by pouring boiling water over it and reducing it to a cream by stirring. Afterwards add 4 lb. sulphate of zinc, 2 lb. common salt previously dissolved in water, and 2 lb. powdered alum.

Limewash. *For Ceilings.*—About 7 lb. of best whiting should be broken small and be allowed to stand in a clean pail, covered with water, for ½ hour. Prepare a pint of starch (as used for linen), also half a cup of dissolved soft soap (about 1 oz.), and mix with the starch. Add this and water to the whiting to make all of the consistency of cream, and then add just sufficient blue to give a brightness to the white. Strain and let stand for 6 or 8 hours. See that the ceiling is quite clean and use good brushes.

For Common Use.—Slake quicklime and stir to a cream. Dissolve alum in boiling water and add to the lime. About 1 lb. of alum is required to a large pailful of lime cream. Two thin coats make a very lasting surface.

Good Limewash.—1 bushel fresh quicklime. Slake with boiling water, putting a sack over the tub to retain the steam. Dissolve 14 lb. common salt in water; boil 14 lb. rice to a paste and stir these in as hot as possible. Add 1 lb. Spanish whiting in powder and 2 lb. glue dissolved to a size. Add more boiling water as required. This should be strained and allowed to stand a day or two. It is then best applied hot.

Kalsomine.—Prepare the wall by going over it with a mixture of 2 lb. of hard soap, 4 lb. powdered alum and 2 lb. glue dissolved in a gallon of boiling water. (The glue should be previously well soaked.) To this may be added cold water to thin it if required. Make the kalsomine by dissolving ½ lb. pale glue in boiling water, 1 lb. powdered alum and 12 lb. Paris white, mixed with water to a good paste. Mix these and try a small portion to see if it binds properly; if not, add more glue. If tints are required, add distemper colours to the Paris white. Thin to required consistency with cold water.

Brilliant Stucco Whitewash for Outside Work, Wood, Brick, or Stucco.—Take 1 bushel of quicklime and slake it with boiling water, covering it during the process. Strain the liquor through fine sieve or strainer, and add to it ½ bushel clean salt dissolved in warm water, 6 lb. ground rice, ground well to a thin paste, stirred boiling hot, 1 lb. powdered Spanish whiting, and 2 lb. clean glue, dissolved in hot water. Add 10 gal. hot water to the whole mixture; stir up well, and let it stand a few days, covered from dirt. It should be put on quite hot; for this purpose it may be kept in a kettle, on a portable furnace. About 1 pint will cover 1 sq. yd.

Lime Paints.—(*a*) For deal floors, wood, stone, and brick work. Dissolve 15 dr. good glue by boiling with thickish milk of lime which contains 1 lb. caustic lime. Then add linseed-oil, just sufficient to form a soap with the lime. This mixture can be used for making up any colour which is not altered by lime. A solution of shellac in borax can be added for brown-red or brown-yellow colours, and is very suitable in painting deal floors. With a coating of varnish or lake, the substances thus painted assume a fine lustre. They can be polished with linseed-oil or turpentine.

(*b*) A lime paint which will bear washing. 3 parts flint, 3 marble fragments and sandstone, 2 calcined white china-clay, and 2 slaked lime, all in powder, furnish a paint to which chosen colours, that may be employed with lime, are added. This paint, by repeated applications, becomes as hard as stone, without losing porosity.

Silicated.—When the surface to be painted is of a mineral nature, such as the exterior of a house, the pigments may be mixed with a vehicle consisting chiefly of water-glass, or soda or potash silicate. This method of painting requires some care, and a knowledge of the chemical nature of the pigments used. Some colours are completely destroyed by the alkali contained in the water-glass. Among those pigments which are not altered by the alkali may be mentioned lime carbonate, baryta-white, zinc-white, cadmium-yellow, Naples-yellow, baryta chromate, chrome-red, red ultramarine, blue ultramarine, cobalt-blue, cobalt-green, chrome-green, ivory-black. When a wall is to be painted, it should first be prepared with a mortar composed of pure fat lime and clean sharp sand. The water used should also be free from saline impurities, as these might subsequently effloresce and destroy the surface of the paint. When the surface of this plaster is dry, a weak solution of water-glass should be applied, and the operation repeated several times. A strong solution cannot be used, because it forms a thin skin on the surface of the plaster, which closes the pores, and prevents the penetration of the water-glass. The pigments are rubbed down with a very weak solution of water-glass, and applied in the ordinary manner. When thoroughly dry, the painted surface is treated with a warm solution of potash silicate applied in the form of a spray. Soda silicate may also be used, but the soda carbonate which is then formed is liable to cause efflorescence. A pigment fixed on the surface of a wall in this manner is as durable as the wall itself, and can be exposed to the weather without any fear of deterioration.

Steatite Paint.—In the United States this is made from a native hydrated magnesia silicate, and is applied to ships' bottoms, to walls for preventing dampness, and to roofs for making them fireproof.

Whiting. — Spanish white and Paris white are practically the same article in different degrees of fineness, all being simply chalk, ground, elutriated, balled, and dried. Grinding mills break up the chalk and mix it with water, which is constantly flowing in. On leaving the mills the mixture passes along a series of wooden troughs, where the sand, which has a greater specific gravity than the chalk, is deposited, the chalk passing on into the settling-pits. On being taken from the pits, the whiting is partially dried on a floor under which hot flues run; then cut up into large rough lumps, and placed in racks on cars which run round on tramways into an immense oven. The heat from the flues in this oven is greatly increased by an air-blast, which also carries off the moist exhalations from the drying whiting; 12 hours on the heated floor and 12 in the oven thoroughly dries the whiting, and it is ready for packing or the putty factory. Paris white of fine quality is used for finishing inside walls, adulterating paints, making paper heavier and whiter, etc. For this purpose, what is called cliff stone, a better and harder quality of chalk, is used. Paris white is made much on the same principle as whiting, only more carefully washed and more slowly dried.

Spanish White.—After picking out the coarser impurities, the chalk is ground in a mill and formed into rolls, in which shape it is found in the trade. For painting purposes, it is still further purified by stirring in clear water, allowing it to settle, and decanting the first water, which is generally yellow and dirty. The washing is repeated, and the chalk is floated out into another vessel, after passing through a silken sieve. After settling the water is decanted, and the pasty white residue is formed into cylindrical rolls, 3 to 4 in. long, and 1½ to 2 in. diameter. These are allowed to harden and dry in the air, and are then ready for painting, whitewashing ceilings, and for distemper painting with size.

Brushes.—*Distemper brushes* are made with the same class of bristle as painting-brushes and dusters. In the former, however, the bristles are 6 in. long, except in the two largest sizes, where they are 6½ in. long. Distemper brushes usually consist of grey middles and white outsides, though they are occasionally made of all black bristles; they may be used for distempering and whitewashing, but they must not be put into limewash of any kind. Distemper brushes are, as a rule, made by tying two knots of bristles on a wooden handle with copper wire, the bristles being arranged like painters' brushes; the same brush unground, and sold at a lower price, is sometimes used for distempering, but it is now practically out of date. Another kind of distemper brush which is coming into use is made with bristle similar to that in the two-knot brush already described, but the bristle, instead of being tied on to a handle in two knots, is inserted in a metal band, after the style of a kalsomine brush, the object being to avoid an opening between the knots, which is of importance in finishing off a good ceiling. Half a century ago bristles were much cheaper than they are at present, and there is still a tendency to higher prices, as the demand becomes greater and the supply lessens. At that time a painting brush which now costs 10*s*. could be bought for half that amount, and the same remark applies to nearly all brushes, and is true in proportion to the weight of good bristle in them. It is to be noted that no foreign-made brush of high quality comes into the English market, and this is owing to the small cost of labour in manufacturing a brush compared with the much greater cost of the bristle used in it, foreign competition being effective only in the item of cheap labour.

Whitewash brushes, described in the makers' catalogues as "stock brushes," are three-knot or four-knot, tied on elm-handled nailed stock, alder-handled nailed stock, flat limer head, and round limer head. The class of bristle used in all is the same as that used in paint brushes, but a little longer, with the exception of the elm-nailed stock, which is usually made with all high-class black bristle. The difference between all the foregoing brushes is this: The two first are tied to handle after the style of a distemper brush; in the next the bristles are fastened by a leather band, which clips them, this band being secured to the handle with large flat-headed nails, driven close together. The two last are similar to the nailed stock—that is, flat or round, the bristles in both being fastened in a similar manner; the stocks only differ in shape, as they are used at the end of a pole, which is inserted obliquely in the stock. All these brushes are made with grey centres and white outsides, like dusters, the limers being usually all grey. These limer brushes must on no account be used in limewash, for it has been pointed out before that lime, especially if freshly slaked, destroys bristle.

A *washing-down brush* is two knot, the bristle used being shorter than that in a distemper brush; it is usually about 5 in. long, and stiff grey. It has become quite the rule with high-class makers to stamp the larger brushes on the handles with the weight of bristle used in them. This should always be looked for by a purchaser, as it will protect him from fraud.

A good *tar brush* is made with grey bristle secured in an iron ring, which also carries a handle driven tightly into it. This is necessary, as there is a great strain on such a brush when in use. Fibre tar brushes are made of all fibre. After being used a few times they may be thrown away as worthless.

WINE COLOURING.

VARIOUS matters are employed to artificially heighten the colours of wines. The following are among the number:

(1) Malva flowers or hollyhock produce, when steeped in spirits for twenty-four hours, or even when boiled with water, a very beautiful purple.

(2) The pokeberry (the dark berries from the plant growing all over the United States) has a very dark red colour.

(3) Whortleberry, elderberry, blackberry, and mulberry.

(4) Brazil-wood, Sanders-wood, and logwood. These woods are boiled in water, and the decoctions yield shades of colour from red to blue.

(5) Cochineal gives a fine red colour by boiling finely-ground cochineal with cream of tartar.

(6) Orchil produces a beautiful purple.

(7) Red beets and carrots produce likewise a good colour.

(8) Indigo solution, neutralised by potash, produces a fine blue.

(9) Annatto and extract of safflower produce a beautiful yellow.

(10) Turmeric is the most common colour for yellow, as the spirit extracts all colour immediately; as also quercitron bark.

(11) Red cabbage produces a beautiful bluish-red.

(12) Gracine (extract of madder) produces various shades of red.

(13) Tincture of saffron (Spanish saffron) for yellow.

(14) Blue vitriol, or solution of indigo, produces blue.

(15) Burnt sugar produces a fine and permanent brown colour for wines. It is best to boil down common sugar or loaf-sugar nearly to dryness. It is then dissolved in hot water, sufficient to make the consistency of syrup; and for the purpose of neutralizing it and making it a more permanent colour, add to each gallon of sugar-colour about 1 oz. liquid ammonia.

(16) Green colour for absinth is prepared from a solution of extract of indigo and turmeric, dissolved in spirits.

(17) Violet is obtained by a solution of extract of logwood and alum.

(18) Barwood acquires a dark wine-red colour by digesting in alcohol.

(19) Brazil-wood, by being macerated in alcohol, or by boiling for half an hour, produces a deep red.

(20) Alkanet-root produces a fine blue-red by macerating in alcohol.

(21) Fuchsine, an aniline colour, is now largely employed as a substitute for ammoniacal extract of cochineal.

◆

WIRE ROPES,

THEIR CARE AND HANDLING, SPLICING, ETC.

Handling Wire Ropes.—When uncoiling wire rope it is important that no kinks are allowed to form, as once a kink is made no amount of strain can take it out, and the rope is unsafe to work. If possible, a turntable should be employed (an old cart wheel mounted on a spindle makes an excellent one). The rope will then lead off perfectly straight without kinks. If a turntable is not available the rope may be rolled along the ground. In no case must the rope be laid upon the ground and the end taken over, or kinks will result, and the rope will be completely spoiled.

The life of wire rope depends principally upon the diameter of drums, sheaves and pulleys; and too much importance cannot be given to the size of the latter. Wherever possible the size of the pulleys should be not less than 700 times the diameter of the largest wire in the rope, and never less than 300 times. The diameter of drums, sheaves and pulleys should increase with the working load when the factor of safety is less than five to one.

The load should not be lifted with a jerk, as the strain may equal three or four times the proper load, and a sound rope may easily be broken.

Examine ropes frequently. A new rope is cheaper than the risk of killing or maiming employees.

All overlapping of wire rope on drums should be avoided where possible.

One-fifth of the ultimate strength of the rope should be considered a fair working load.

In shafts and elevators, where human life is constantly raised and lowered, the working load should not be more than one-tenth of the ultimate breaking strength of the rope.

To increase the amount of work done, *it is better to increase the working load than the speed of the rope.* Experience has shown that the wear of the rope increases with the speed.

Wire Rope should be greased when running or idle.—Rust destroys as effectively as hard work.

Galvanised wire rope should never be used for running rope. One day's use will wear off the coating of zinc, and the rope will soon begin to rust.

Great care should be taken that the grooves of drums and sheaves are perfectly smooth, ample in diameter, and conformed to the surface of the rope. They should also be in perfect line with the rope, that the latter may not chafe on the sides of the grooves.

Pulleys.—It is of the greatest importance that the pulleys over which the rope has to run are turned out in the groove of an exact radius to fit the rope, as in Fig. 299.

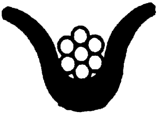
FIG. 299.

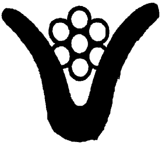
FIG. 300.

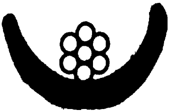
FIG. 301.

V grooves, which do not allow the rope to work freely in the tread of the grooves, destroy the rope in a very short time, the wires and strands being displaced when the rope is pulled out of the groove, as in Fig. 300.

Another evil, although of lesser extent, is where a rope is put to work on a pulley where the groove is too large

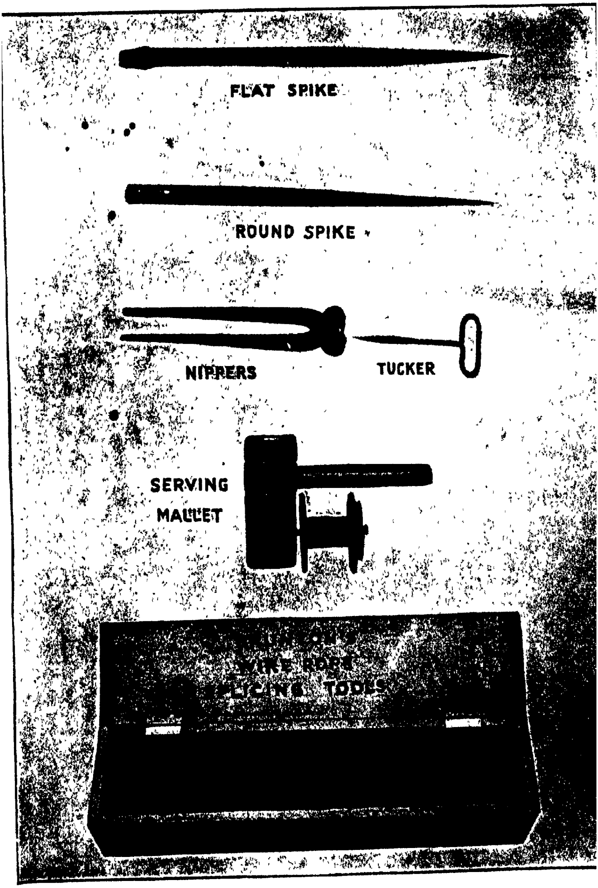

FIG. 302.

for it (Fig. 301). This causes undue stress on individual wires, and you get a line of broken wires in the rope.

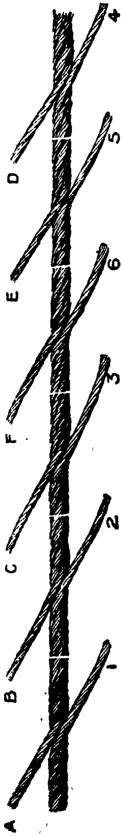

FIG. 303.

Splicing Tools.—The usual splicing tools are shown in Fig. 302. They include a tucker for small strands splicing; round marlinspike; flatter marlinspike; steel wire-cutters; and serving mallet. These are made in sets by Messrs. Brunton and Sons, the manufacturers of Kilindo wire rope, or can be obtained from most engineers' supplies stores.

To make an Endless Splice. Clamps are applied to the rope sufficiently far back from the ends to allow plenty of room for the splice, and the men to operate in. The two ends are then drawn together by means of blocks and tackle, until they overlap each other for a space of 20 to 30 ft., according to the size of the rope. At a point from each end, midway of the lap, the rope must be bound with a good serving of No. 18 or No. 20 annealed wire. The serving at the extreme ends is then cut off, the strands untwisted to the new serving, and the hemp cores also cut off so as to abut when the open bunches of strands are brought together, and the opposite strands interlaced, regularly with each other, presenting the appearance as near as can be shown (Fig. 303).

After these are all correctly interlaced pull the ropes tightly together, so that the cores abut against one another. Next take strand No. 1, and, as it is being unlaid, follow it up with strand A, which must be laid into its place tightly until within 5 ft. from the end. Strand No. 1 is then cut off, leaving it 5 ft. long, same length as A strand. The remaining strands are treated the same way, three alternate strands being laid towards the right hand and three to the left. The strands being now all laid in their places, the ends are cut off, as with the first strands, to 5 ft. The appearance of splice will now be the same as in Fig. 304.

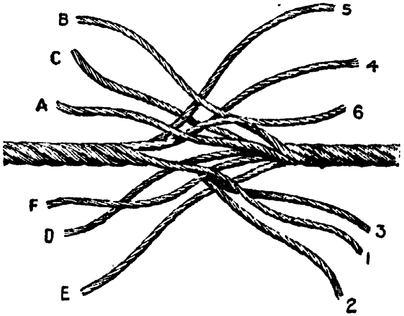

FIG. 304.

The next thing is to tuck in the ends, and this is where the skill comes in. *Before doing this, care should be observed to see that the spliced portion of the rope is perfectly limp, or free of tension, otherwise this operation cannot be well performed.* The core is then cut and pulled out on the side corresponding with the end to be tucked in for a distance equal to the length of the end which is to replace it. It is desirable, especially if the rope is composed of small wires, to tie the ends of the strands with soft twine or threads of jute yarn in order to keep the wires well bunched. A marlinspike is then passed over 1 and under two of the strands, when the core is cut off at the proper point, and by moving the spike along the rope spirally with the strands, the loose end 1 is passed into the core space and the spike withdrawn. Then pull out the core on the other side, pass the marlinspike over A and under two strands as before, cut off the core, and tuck in the end A in precisely the same manner, after which the rope is twisted back again as tightly as possible, and the clamps or other appliances that may be used are removed to the next pair of projecting ends. Any slight inequality in the symmetrical shape of the rope may be taken out by pounding with a wooden mallet. Some prefer to tuck in first all the ends projecting in one direction, and then the ends projecting the other way; it is immaterial in what order they are tucked in.

If these directions are explicitly followed, the spliced portion of the rope will be of uniform diameter with other portions, and present a smooth and even appearance throughout. After running a day or two, the locality of the splice cannot be readily detected, and the rope will be quite as strong in this portion as any other.

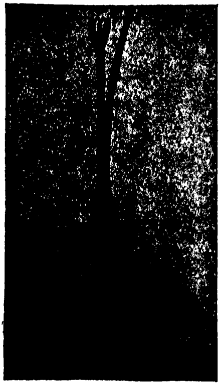

FIG. 305.

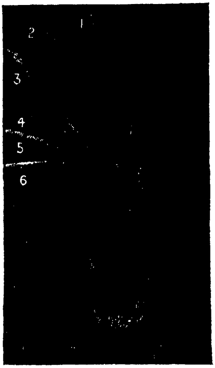

FIG. 306.

Splicing Thimbles. *Under and Over Style.*—Ordinary type of wire rope. Serve the rope with wire or tarred yarn to suit the circumference of the thimble, bend round thimble and tie securely in place with temporary lashing till splice is finished (as in Fig. 305). Open out the strands (as in Fig. 306), taking care to keep the loose end of the rope to the left hand. Now insert marlinspike, lifting two strands (as shown in Fig. 307), and tuck away towards the right hand (that is, inserting the strand at the point, and over the spike) strand No. 1, pulling the strand well home. Next insert marlinspike through next strand to the left, only lifting one strand, the point of the spike coming out at the same place as before. Tuck away strand No. 2 as before.

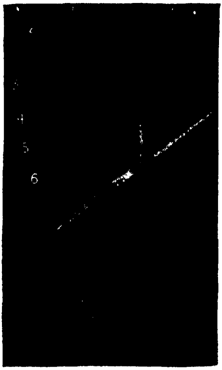

FIG. 307.

FIG. 308.

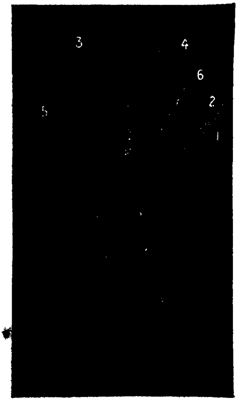

FIG. 309.

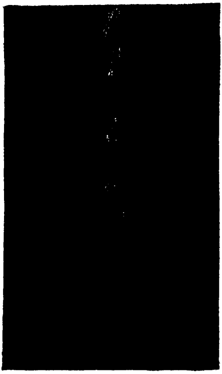

FIG. 310.

The next tuck is the *locking tuck*. Insert marlinspike in next strand, and missing No. 3, tuck away strand No. 4

from the point of the spike towards the right hand. Now, without taking out the spike, tuck away strand No. 3 *behind the spike towards the left hand* (as shown in Fig. 309). Then insert spike in next strand, and tuck away strand No. 5 behind and over the spike. No 6 likewise. Pull all the loose strands well down.

This completes the first series of tucks, and the splice will, if made properly, be as Fig. 308. Now, starting with No. 1 and taking each strand in rotation, tuck away under one strand and over the next strand till all the strands have been tucked four times. If it is intended to taper the splice, the strands may at this point be split, and half of the wires being tucked away as before, the other half cut close to the splice. Fig. 310 shows the finished splice ready for serving over.

It will be noticed that this style of splice possesses a plaited appearance, and the more strain applied to the rope, the tighter the splice will grip, and there is no fear of the splice drawing owing to rotation of the rope.

Liverpool or Spiral Style. — (See Fig. 311).—Hawsers, or any ropes not hanging free and liable to spin, may be spliced in this style, in which the strands, instead of being interlocked together, are merely tucked round and round one particular strand in the rope. Each loose strand is, of course, tucked round a different strand in the rope. This is sometimes called the "Liverpool" style.

Splicing Thimbles in "Kilindo" Ropes.—Serve rope with soft wire or tarred yarn. Bend round thimble and securely lash in place till splice is finished (as shown in Fig. 306). Open out loose end of rope, spreading out all the strands (as shown in Fig. 312), taking care that no two strands cross. The strands are then tucked away (Fig. 313), two or more at a time, in exactly the same way as described above. If it is wished they may be tucked spirally—that is, round and round one particular strand, as in Liverpool splice. Being a non-rotating rope, it is not necessary to have a locking tuck in "Kilindo" rope, but it is recommended (see Fig. 313). Fig. 314 shows completed splice. It is

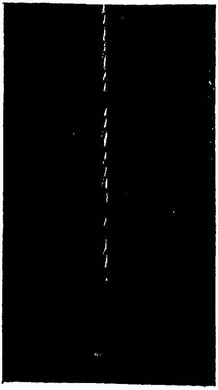

FIG. 311.

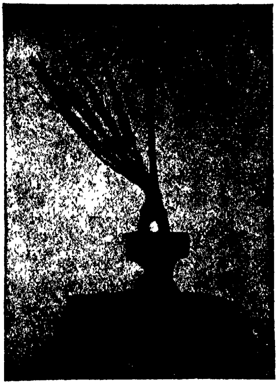

FIG. 312

most important that all the strands are tucked away, otherwise the splice will not stand breaking strain of rope, and also if it is omitted to tuck the inside strands, these will have a tendency to creep upwards, and will eventually break through the outer strands.

Crosby clips (as shown in Fig. 315) are recommended when a splicer is not obtainable, and they are quite safe.

Endless "Kilindo" Splice.—Serve the rope tightly at a point about twenty feet from each end, and unlay the outer cover of strands *en masse* to this point, taking care to leave the inside rope intact. Splice the inside rope in exactly the same way as already described. Then lay back the outer covering of strands till they meet at the centre of the splice. If this is done carefully, it will be found that the rope will be perfectly symmetrical, the strands folding into their positions quite easily. Then interlace the various strands at the centre of the splice, and unlay one strand, following up with the strand opposite, exactly as with an ordinary splice. When all the strands are laid into their place, proceed to tuck away as follows: If the rope is of eight strands, lift two strands with the marlinspike, and pull the strand to be tucked right through the aperture intact. Pull out the spike and unlay the wires in the strand, and repeat the above process twice. Cut off close and lay inside the rope, and it will be found that the wires will fit quite snugly in the interstices of the inside rope, without forming any apparent thickening of the rope. Repeat with all the strands to be tucked.

FIG. 313.

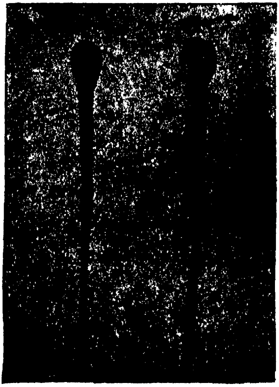

FIG. 314. FIG. 315.

Fixing Improved Wir Sockets.—Put the socket over tl wire rope as shown in Fig. 316, ar about 6 in. from the end. Serve wi fine wire for about 1½ in., then op the strands, cut off the heart, and ben all the strands back over the servi as shown in Fig. 317.

They should then be tucked in b tween the strands as shown in Fi 318, and the whole hammered close together.

A steel pin should then be driven as in Fig. 318.

The rope is then drawn down in

the socket as shown in Fig. 319, and the whole run up with hard white metal.

A good mixture of white metal to run up wire rope sockets is equal parts of tin, lead, and zinc.

An Improved Hose or Socket. In view of the difficulty often experienced in the re-capping of winding ropes, King devised a detachable socket or hose, which may be put on or taken off without the necessity of heating the shackle-end. Instead of being made in one piece, the new hose (Figs. 320 and 321) is built up of two sidepieces connected at the top to a suitable stirrup, the whole being ringed in the usual manner. The method of attachment is as follows: The rope is covered with soft annealed iron wire to a point about 9 in. from the end of the rope A. The wires are allowed to unstrand from this point to B, and when completely separated are dipped into a pail of dilute acid to clean them. The acid is then shaken off. The hose, C and D, is then built up round the end of the rope, the wires being loosely bound at the extreme top into the shape of the conical recess in the socket. The stirrup, EF, the washer, K, are fixed in place, the sides of the hose are clayed up, and the whole filled with white metal. The rings, G^1, G^2, and G^3, are driven home when the metal has cooled, the stirrup, EF, then being finally screwed up tight by the bolt, H, and nut, I (Figs. 320 and 321). The capel can be fixed complete in 15 minutes after the wires are separated and cleaned. When tested this hose held the rope so firm that it broke clear and there was no sign of slip. A special advantage of this hose is that it can readily be taken off and the butt end of the rope examined, to ascertain if the white metal has united properly with the wires. This advan-

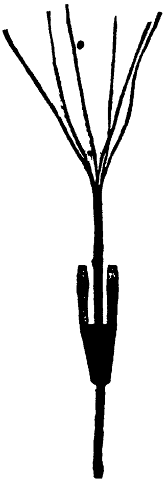

FIG. 316.

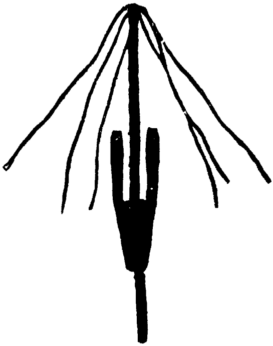

FIG. 317.

tage is possessed by no other white metal hose, and is important. If a perfect solid butt is shown no power can draw the rope out of the hose.

Preservation of Winding Ropes.—(*a*) In a recent report of the Transvaal Commission appointed to investigate the use of winding ropes and safety appliances in mines some interesting facts were given. In the first place, it is shown that the preservative treatment of a rope during its manufacture is a matter of first importance, and directly influences the life of the rope. The core, of tarred Russian hemp, should be thoroughly soaked in an acid-free lubricant, and the wires should also be well lubricated whilst they are being laid up. The rope thus, if the dressing is sufficiently thick and heavy, is well prepared to resist the corrosive action of a damp atmosphere. Ropes are usually coated with a black varnish for shipment abroad, but such ropes should be well treated with a lubricating dressing before they are put to work, in fact, this remark applies to all winding ropes. Suitable dressings of various kinds are advocated. Many manufacturers favour plumbago or graphite mixed with vaseline, linseed-oil, palm or other vegetable oil. Some of the workmen who gave evidence before

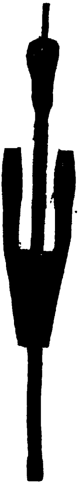

Fig. 318.

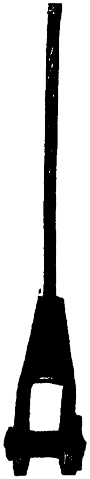

Fig. 319.

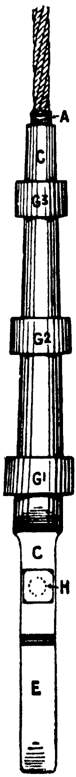

Fig. 320.

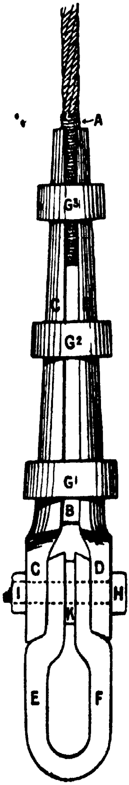

Fig. 321.

the Transvaal Commission held widely different views on this point; one favoured Stockholm tar with grease, another one advocated the use of a mixture of one part of cylinder oil to two parts of truck grease, whilst a third made a practice of using a patent composition. A point well worth the attention of users of hauling ropes is to watch very carefully that the tread of the sheave does not become filled up with a dressing which is liable to harden on exposure, because cases have been known when the rope has been thrown off the sheave due to the accumulation of such lubricant, i.e. to the tread having become full up.

With regard to the effect of working conditions on the life of the rope, one manufacturer said: "A winding rope, made to suit the special winding apparatus at a mine, should only depend upon the number of foot-pounds of work done for its life. The more material lifted from the mine, or the quicker that it is lifted, bears a direct proportion to the life of the rope."

The conditions under which ropes are used must be considered in the first place, for very often when provision is made to protect a rope under one or more known conditions, that same provision has quite the reverse effect when other conditions come into play. This simply amounts to saying that, as in the case of all other plants for engineering work, the manufacturers should be consulted before the material for any given job is obtained, as it is only natural that they know more about the suitability of their manufactures than anyone else. Amongst other considerations which have to be dealt with in mine work, the fact of high speed of lifting was given much attention. Rapid winding was considered, generally speaking, more harsh than slow winding, even though bigger loads were carried in the latter case. This is accounted for by the sudden changes of velocity when high speeds are used, and not merely on account of the speed in itself being high. Another factor which tends to shorten the life of a winding rope very considerably is the pinching effect which occurs at each end of the winding-drum when the rope mounts upon the layer immediately beneath it. If special flanges are used, such as those constructed to the design of Mr. H. C. Behr, consulting mechanical engineer to the Consolidated Gold Fields of South Africa, Ltd., this effect is entirely obviated. Another cause of severe wear and tear is the side friction of one coil of rope upon the next, and also upon the lower coils on which it is bedding. This may be due to too short a lead from sheave to drum. The angularity of the sheave at the pit head and the horizontal distance of the drum from the shaft should so conform to the width of the drum that the deviation of the rope is not too great. If this angle becomes more than two degrees on each side of the centre line, considerable side friction on the rope will be introduced, moreover, the coiling of the rope on the winding-drum may possibly give trouble. In such cases, where grooved drums are used, a deviation from the straight line may, of course, be considerably greater.

The life of a haulage rope may be prolonged to a very great extent if the following precautions are minutely observed and carried out:—

(1) The rope should be protected from water as much as possible, and carefully treated with a good lubricant at least once a week.

(2) The haulage wheels, roller pulleys and bevel pulleys should receive attention, and be lubricated at least once a day.

(3) The rope should be carefully guided, and not allowed to rub on the roof, sides or floor of the roadway.

(4) The haulage wheels should be as large as possible to avoid quick curving of the rope.

(5) The rope should never be subjected to sudden jerks.

(6) It should never be loaded beyond the safe working load.

(7) A haulage rope should never be

changed from a larger to a smaller drum, but it will do no harm to change it from a smaller to a larger.

(8) It should be recapped and reversed at least every six months.

(9) The rope should be minutely examined at frequent intervals, and portions of it tested regularly.

The following ingredients, in varying proportions to suit conditions, make a very good lubricant for ropes, and is not costly:—Tar, summer oil, mica and axle grease. The tar and oil must be absolutely free from acids of any kind. The above combination resists water successfully and thoroughly penetrates the wires, thereby preventing rust, and fills the cable, giving it a solid appearance.

As regards the storing of ropes: they should on no account be placed on the ground, but upon dry planks raised a few inches so that they will be entirely free from damp. They should be carefully covered, and should be inspected frequently, besides having a coating of some lubricant at intervals.

When uncoiling a new rope the greatest care should be taken to prevent "kinking"; they should during the process be placed on a reel or drum when being "given" out. (J. MacVie in 'Mining Engineering.')

Lubricating Ropes and Guides.—In "Glückauf" Mr. Dobbelstein describes certain devices recently introduced into German mining practice for greasing cage-ropes and guides, on account of the waste and imperfect manner in which the work is done by hand. At the Hugo colliery of the Harpener company a hinged wrought-iron casing is arranged in connection with a compressed-air pipe. The rope passes through a central bore of the casing, and engine oil (which possesses the necessary fluidity and prevents rusting) is forced through a number of small orifices at an angle of 45° with the rope. The bore of the casing is eased at the top and bottom, to prevent loose ends of wire from being torn out of the rope; and the casing is mounted on rollers, so as to follow any deviations of the rope from the centre of the winding compartment. The consumption of oil is only one-sixth that of the solid grease previously used; and there is also a considerable saving in labour, one man being able to put the apparatus in position for use, whereas hand greasing takes three men a full day. Experiments made with a view to obtaining an efficient, non-slipping, anti-corrosive lubricant for underground haulage ropes showed that the best results for this purpose are obtained by a mixture of tar and driers, this possessing the requisite tenacity and elasticity. The problem of greasing cage-guides is somewhat difficult, oil or grease being prohibited on account of the danger of fire, whilst soft soap soon washes off in wet shafts, and is also wasteful in application by hand. A thin mixture of soap and graphite was eventually prepared, which greatly lessens the friction of the cage shoes on the guides, and can be applied by compressed air. For this purpose a closed vessel, divided into two compartments, for the grease and air respectively, is mounted on tub wheels, and charged with compressed air from the main until a constant pressure is indicated by the gauge. The mounted vessel is run into the cage, and a branched delivery pipe leading from the oil chamber is fitted with two pairs of nozzles that pass through holes in the side of the cage and discharge the grease on to the inner corners of the cage-guides as the cage moves down the shaft, the compressed air being admitted to the oil chamber through a reducing-valve. A saving of about 20*l.* per annum is effected by the use of this device.

END OF VOLUME IV.